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ABSTRACTS

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Abstracts for Thematic Sessions

Thematic Session 1 : Some recent advances in elliptic and parabolic PDEs

Introduction: This thematic session aims to showcase several important recent advances in elliptic and parabolic PDEs, by leading researchers in the field of PDEs and their applications, who will either speak in the session or publish a survey article in the Conference Thematic Issue of the AIMS flagship journal Discrete and Continuous Dynamical Systems. We hope this session will inspire further collaborations and breakthroughs in research in the broad area of elliptic and parabolic PDEs.

Nonuniform Ellipticity and Nonlinear Potentials

Schedule: July 8 14:20-15:10 Room AULA

Cristiana De Filippis

University of Parma, Italy

Abstract:

The representation formula for the Poisson equation gives an explicit expression of solutions in terms of the data, yielding zeroth- and first-order pointwise bounds via convolution with suitable Riesz potentials. Their mapping properties allow for a sharp regularity transfer from data to solutions, so that nonlinear PDEs can be treated, up to the C^1 -level as they were linear. I will then discuss a novel potential-theoretic approach to the (ir)regularity of solutions to certain nonuniformly elliptic PDEs arising in geometric and physical models. From recent, joint work with Jan Kristensen (Oxford) and Giuseppe Mingione (Parma).

Bifurcation and Pattern formation in reaction-diffusion models with nonlocal advection and time delays

Schedule: July 8 15:10-16:00 Room AULA

Junping Shi

College of William & Mary, USA

Abstract:

Reaction-diffusion equations with nonlocal advection and time delays arise naturally in ecological and biological systems where movement is influenced by spatially distributed information, such as perceived resource landscapes or memory of previously visited locations. These models incorporate cognitive or behavioral mechanisms by allowing individuals to respond to environmental signals averaged over spatial regions and past times. We review several classes of reaction-diffusion models in which advective movement is governed by spatiotemporal information of population distributions. Different types of advection potentials lead to distinct forms of nonlocal advective forces. When the nonlocal interaction is sufficiently attractive or repulsive, symmetry-breaking bifurcations occur, producing aggregation or segregation patterns, as well as time-periodic solutions that persist as asymptotic states.

On Brezis' two open questions

Schedule: July 8 13:30-14:20 Room AULA

Juncheng Wei

Chinese University of Hong Kong, Hong Kong

Abstract:

In 2023, H. Brezis published 28 open problems which he described as 'raised throughout my career and that have resisted so far'. In this talk, we present complete solutions to the first and seventh problems: Problem 1.1. Let $\lambda \in (0, \frac{1}{4})$ and B_1 be the unit ball in $\mathbb{R}^3$. Are there nontrivial solutions to

$$-\Delta u = u^5 + \lambda u \text{ in } B_1; u = 0 \text{ on } \partial B_1?$$

Our answer: Yes. There are infinitely many non-radial sign-changing solutions. (Joint work with Liming Sun and Wen Yang.) Problem 3.1. Let B_1 be the unit disk in $\mathbb{R}^2$. Consider the harmonic map problem $u : B_1 \rightarrow S^2$

$$-\Delta u = |du|^2 u \text{ in } B_1; u = (Rx, Ry, \sqrt{1 - R^2}) \text{ on } \partial B_1$$

It is well-known that there are at least two explicit solutions. Are there more solutions? Our answer: Yes. There are infinitely many distinct solutions. (Joint work with Fanghua Lin.)

Thematic Session 2 : Curvature Flows and Geometric Inequalities

Introduction: This session explores recent advances in the study of curvature flows and their connections with geometric inequalities. Curvature flows, such as mean curvature flow, Ricci flow, and other fully nonlinear flows, have been powerful tools in geometric analysis, with deep implications for topology, PDEs, and mathematical physics. A central theme is the interplay between evolving geometries and sharp geometric inequalities, including isoperimetric, Sobolev, and Alexandrov-Fenchel-type inequalities. The session aims to foster discussions among researchers working at the intersection of geometric analysis, PDEs, and differential geometry, highlighting new techniques and open problems in this vibrant field

Inverse mean curvature flow and Steklov eigenvalue in hyperbolic space

Schedule: July 6 13:30-14:20 Room 204

Haizhong Li

Tsinghua University, Peoples Rep of China

Abstract:

In this talk, by inverse mean curvature flow we establish optimal Weinstock inequality for the first non-zero Steklov eigenvalue on star-shaped mean convex domains in hyperbolic space H^n . In particular, when the domain is convex, we give an affirmative answer to an open question by Colbois-Girouard-Gordon-Sher.

Inverse curvature type flows and geometric inequalities

Schedule: July 6 14:20-15:10 Room 204

Yong Wei

University of Science and Technology of China, Peoples Rep of China

Abstract:

I will describe some recent work on locally constrained inverse curvature flows for hypersurfaces and their applications in proving geometric inequalities. These flows were first introduced by Brendle-Guan-Li in the case of space forms and were recently extended to cases with boundaries. The flow speed involves higher-order mean curvature and includes a local term designed to preserve certain natural geometric quantities, such as quermassintegrals. We show that the flow has a natural monotonicity property, preserves some convexity, and exhibits long-time existence and convergence. These results can be applied to establish isoperimetric-type geometric inequalities for hypersurfaces.

Thematic Session 3 : Reaction-diffusion equations, new theoretical and applied trends

Introduction: The aim of this session is to give an overview of the recent progresses in the mathematical analysis of reaction-diffusion equations and systems. The talks, given by renowned experts of the field from different continents, will present some recent results on theoretical and more applied aspects of reaction-diffusion equations, in particular on the description of the large time dynamics of the solutions, the related propagation phenomena, and the mathematical analysis of biological invasions.

When Distant Regions Drive Invasion: Nonlocal Pulling in Heterogeneous Media

Schedule: July 6 14:20-15:10 Room AULA

King-Yeung Lam

Ohio State University, USA

Abstract:

Propagation in heterogeneous and shifting environments is a central problem in ecology and reaction-diffusion theory. Motivated by classical conjectures of Shigesada-Kawasaki and recent works on shifting habitats, we study invasion phenomena in competition systems and their reduction to scalar KPP-type models. We develop a Hamilton-Jacobi framework based on viscosity solutions to characterize spreading speeds and front dynamics. In particular, we derive a variational formula for the propagation speed and identify regimes where invasion exhibits nonlocal pulling, whereby the spreading speed is determined by distant favorable regions rather than local conditions near the invasion front. We further extend this framework to non-monotone environments, where the limiting problem may have non-unique solutions. This issue is resolved by introducing appropriate junction conditions and flux-limited solutions in the sense of Imbert-Monneau. This project is a joint work with Gregoire Nadin, Chang-Hong Wu and Xiao Yu.

PROPAGATION PHENOMENA OF FISHER-KPP EQUATIONS IN HETEROGENEOUS MEDIA VIA GENERALIZED PRINCIPAL EIGENVALUE

Schedule: July 6 13:30-14:20 Room AULA

Xing Liang

University of Science and Technology of China, Peoples Rep of China

Abstract:

In this talk, some recent advances on the propagation phenomena of Fisher-KPP type reaction-diffusion equations in one-dimensional heterogeneous media are presented, covering aspects of local dispersal, nonlocal dispersal, and dispersal in discrete spaces. As the main tool, we also introduce the theory of generalized principal eigenvalues in these cases.

Structural Models, Eigenvalues, and Biological Evolution

Schedule: July 6 16:30-17:20 Room AULA

Yuan Lou

Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

The Centipede Game leads to a counterintuitive Nash equilibrium that destroys wealth. We study this game and investigate versions of the game that lead to a model of formation and burst of financial bubbles, where participants are first incentivized to feed the trend, then run for the exit. We analyze these mechanisms and examine how the model fits behavioral economics interpretations and the observed dynamics of financial bubbles.

Stationary solutions for the heterogeneous Fisher-KPP equation

Schedule: July 6 17:20-18:10 Room AULA

Luca Rossi

Sapienza University of Rome, Italy

Abstract:

Does the heterogeneous Fisher-KPP equation admit a unique stationary solution? We will present a positive result which is valid up to dimension 6. Then we will see that some surprises occur in higher dimension. This is a joint work with O. Tough.

Cross-diffusion systems

Schedule: July 6 15:10-16:00 Room AULA

Angela Stevens

University of Munster, Germany

Abstract:

Cross-diffusion systems play a major role in many applied contexts. One of the many interesting challenges is to classify parameter regimes for global existence or blow-up of their solutions. In order to prove global existence of solutions we introduce a new energy functional, which is motivated by the transformation matrix given by Oelschläger in 1989, and which he used to rigorously derive cross-diffusion systems from moderately interacting stochastic many particle systems under the condition that the limiting PDE-system has regular solutions. We compare our findings with more recent results on the existence of solutions for cross-diffusion systems. (Joint work with Kyungeun Kang)

Thematic Session 4 : Hyperbolic and mixed-type problems in fluid dynamics

Introduction: The thematic session brings together leading experts to exchange the latest results and advancements in hyperbolic and mixed-type problems in fluid dynamics. It focuses on shock reflection, transonic flows, shock waves, singularity formation, viscous fluid flows, and stability in compressible flows and conservation laws. The session aims to explore new connections and ideas and promote interactions among experts in challenging areas.

Multidimensional Riemann Problems - Transonic Shock Waves and Free Boundary Problems

Schedule: July 7 13:30-14:20 Room AULA

Gui-Qiang Chen

University of Oxford, England

Abstract:

In this talk, we will discuss global solutions of multidimensional Riemann problems for nonlinear hyperbolic systems of conservation laws, with emphasis on their global patterns and structures. We present recent progress in the rigorous analysis of several longstanding two-dimensional Riemann problems both initial and lateral involving transonic shock waves for the Euler equations for potential flow. In particular, we focus on the four-shock Riemann problem for the Euler equations for potential flow, as a representative example, to illustrate how these problems can be reformulated and solved as free boundary problems, with transonic shock waves serving as free boundaries for the corresponding nonlinear conservation laws of mixed elliptic-hyperbolic type. We further address several physically significant lateral Riemann problems, including Prandtl's reflection problem and von Neumann's shock reflection-diffraction problem. Moreover, we present different regularity properties of Riemann solutions to the compressible Euler equations for both potential and isentropic flows. We also discuss additional multidimensional Riemann problems and related shock-wave problems for nonlinear partial differential equations, if time permits.

Concentration of weak solutions in compressible flows

Schedule: July 7 14:20-15:10 Room AULA

Xianpeng Hu

The Hong Kong Polytechnic University, Peoples Rep of China

Abstract:

We will discuss some recent progress in the concentration phenomenon of weak solutions for compressible flows. We will focus on two typical examples, compressible viscoelasticity and compressible Navier-Stokes equations. Some new observations, including the uniform bounds on localised fluid momentum and its Riesz potential in Orlicz spaces, will be discussed.

Oscillations in hyperbolic-parabolic systems and homogenization via kinetic equations

Schedule: July 7 15:10-16:00 Room AULA

Athanasios Tzavaras

KAUST/Applied Mathematics and Computational Science, Saudi Arabia

Abstract:

We present examples of sustained oscillations for hyperbolic-parabolic systems. In the existence theory for viscoelasticity of Kelvin-Voigt type, oscillations on the deformation gradient can persist and propagate in time. The existence of sustained oscillations is demonstrated in two classes of systems: (i) Examples from nonlinear viscoelasticity with elastic strain energy that is not rank-1 convex, and (ii) in the compressible Navier-Stokes system with non-monotone pressures. The subject naturally leads to the problem of deriving effective equations for the associated homogenization problems. This problem is addressed using ideas from the kinetic formulation for conservation laws. One derives homogenization equations for oscillations of the density in one-dimensional models of viscoelasticity with non-monotone stresses and also for the compressible Navier-Stokes system with nonmonotone pressures. This leads to effective systems consisting of kinetic equations coupled with the macroscopic flow.

Thematic Session 5 : Mathematical Modelling and Numerical Simulations

Introduction: This thematic session on $\diamond$ Mathematical Modeling and Numerical Simulations of Complex Dynamics $\diamond$ brings together three leading experts to address the critical challenges and recent advances in this important area of applied and computational mathematics. As studies of complex systems become increasingly central to a wide range of scientific and engineering disciplines, the development of effective modeling and computational tools is playing a more vital role than ever. The session will showcase cutting-edge methodologies that bridge theoretical analysis with computational practice, offering insights into nonlinear, multiscale, and high-dimensional problems. By fostering discussion among researchers, the session aims to catalyze exchanges of novel ideas and inspire innovative approaches for tackling the intricate behaviors that define complex systems.

Mathematical modelling and numerical simulations for solid-state dewetting problems

Schedule: July 7 13:30-14:20 Room 204

Wei Jiang

Wuhan University, Peoples Rep of China

Abstract:

Solid-state dewetting is a ubiquitous phenomenon observed in thin film materials. It describes the process by which a solid thin film spontaneously breaks apart and forms micro/nanoparticles or specific morphological structures through surface diffusion and interfacial energy minimization. This phenomenon has significant applications in materials science and nanotechnology. This talk will briefly review the author's research progress over the past decade in the theoretical study of solid-state dewetting, focusing primarily on how to establish sharp-interface models and phase-field models to describe this phenomenon, as well as how to design efficient numerical algorithms for solving these models. Additionally, the author would like to convey the joy of discovering and solving scientific problems in engineering, particularly those related to applied and computational mathematics.

Model-consistent data-driven computational strategies for PDE joint inversion problems

Schedule: July 7 14:20-15:10 Room 204

Kui Ren

Columbia University, USA

Abstract:

The task of simultaneously reconstructing multiple physical coefficients in PDEs from observed data is ubiquitous in applications. We propose an integrated data-driven and model-based iterative reconstruction framework for such joint inversion problems where additional data on the unknown coefficients are supplemented for better reconstructions. Our method couples the supplementary data with the PDE model to make the data-driven modeling process consistent with the model-based reconstruction procedure. This coupling strategy allows us to characterize the impact of learning uncertainty on the joint inversion results for two typical inverse problems. Numerical evidence is provided to demonstrate the feasibility of using data-driven models to improve the joint inversion of multiple coefficients in PDEs.

High-Order Structure-Preserving Product-type Runge-Kutta Methods for Gradient Flow Models with Variable Mobility

Schedule: July 7 15:10-16:00 Room 204

Jiang Yang

Southern University of Science and Technology, Peoples Rep of China

Abstract:

Gradient Flow Models serve as essential mathematical tools for describing evolutionary laws in nature, with extensive applications in the heat equation, phase-field equations, Ricci flow, surface minimization problems, and stochastic gradient descent algorithms in machine learning. In numerical simulations, the rigorous preservation of the original energy dissipation law remains a core challenge in this field. While classical algorithms-such as stabilization methods, convex splitting, invariant energy quadraturization methods, scalar auxiliary variable methods, and implicit-explicit/exponentialtime-differencing Runge-Kutta methods-have achieved significant success for constant-coefficient models, existing algorithms face limitations in balancing structure preservation and computational efficiency when dealing with nonlinear variable mobility. To address these challenges, this report proposes a suite of innovative high-order Product-type Runge-Kutta (P-RK) methods. By investigating three representative nonlinear models, we demonstrate the superior performance and flexibility of the proposed methods in structure preservation:

- Dirichlet Harmonic Map Gradient Flow: By constructing appropriate P-RK methods combined with a normalization post-processing step, we achieve dual structure preservation of the energy dissipation law and the unit-length constraint ($|u| = 1$). To the best of our knowledge, this is the first second-order scheme that maintains both structures while maintaining linear computational complexity.
- Anisotropic Dendritic Growth Phase-field Model: By introducing P-RK methods with multi-block Butcher tableaus, we develop an efficient decoupled algorithm that strictly follows the original energy dissipation structure while significantly enhancing computational efficiency.
- Variable-mobility Allen-Cahn Equation: By constructing appropriate P-RK methods combined with a cut-off post-processing technique, we achieve unconditional preservation of both the original energy dissipation and the Maximum Bound Principle (MBP). To overcome the difficulties in optimal error estimation caused by truncation post-processing, we propose a time two-grid method, which successfully restores the optimal convergence order.

Both theoretical analysis and numerical experiments demonstrate that the proposed methods possess significant advantages in structure-preserving properties, numerical stability, and computational accuracy. This work provides a new theoretical framework and numerical tools for the efficient and high-performance simulation of complex gradient flow systems.

Thematic Session 6 : Mathematical developments in general relativity

Introduction: The mathematical study of general relativity has witnessed a resurgence of activity in recent years. This thematic session will feature several aspects of the most recent developments in the theory, concerning in particular the problem of stability of classical black hole solutions, the complicated question of near-extremal behaviour, and the so-called third law of black hole thermodynamics.

The threshold conjecture for extremal black holes in spherical symmetry

Schedule: July 6 16:30-17:20

Yannis Angelopoulos

Beijing Institute of Mathematical Sciences and Applications, China

Abstract:

I will present some recent results, obtained jointly with Kehle and Unger, on the stability and instability properties of extremal Reissner-Nordstrom black holes in the context of the Einstein-Maxwell-neutral scalar field system of equations in spherical symmetry.

The third law of black hole thermodynamics and extremal critical collapse

Schedule: July 6 18:10-19:00

Ryan Unger

University of California, Berkeley, USA

Abstract:

Extremal black holes are special solutions of Einstein's equations with absolute zero temperature in the celebrated thermodynamic analogy of black hole mechanics. Bardeen, Carter, and Hawking conjectured in 1973 that extremal black holes cannot form dynamically in gravitational collapse, namely, that it should not be possible to reduce the temperature of a black hole to zero in finite time. In this talk, I will explain how recent developments in the mathematical theory of general relativity have led to the disproof of this third law of black hole thermodynamics and have furthermore revealed that extremal black holes play a key role in the phase transition from dispersion to black hole formation in the moduli space of solutions to the Einstein equations. This is based on joint work with Christoph Kehle (University of Zurich).

Kerr-de Sitter spacetimes: Stability of the black hole exterior and of the expanding region of Kerr-de Sitter spacetimes

Schedule: July 6 17:20-18:10

Andras Vasy

Stanford University, USA

Abstract:

Based on joint work with Peter Hintz and partly with Oliver Petersen, I will discuss the nonlinear stability of Kerr-de Sitter spacetimes as solutions of the Einstein vacuum equations with positive cosmological constant. Building on our unconditional earlier stability work for slowly rotating Kerr-de Sitter black holes, the first part concerns the conditional stability of a neighborhood of the black hole exterior (more precisely, the domain of outer communication) in the subextremal range of black hole parameters, namely stability under the assumption of mode stability for the linearized Einstein equation, which I will explain. The second part discusses the stability of the expanding (cosmological) region in a modification of a generalized harmonic gauge introduced by Ringström; in a different type of gauge such a result was obtained recently by Fournodavlos and Schlue. Due to the hyperbolic character of the gauge, the stability result is local near points on the conformal boundary. I will also discuss the smoothness of the metric up to the future conformal boundary, with a Fefferman-Graham type asymptotic expansion, as a consequence of the stability proof.

Abstracts for Special Sessions

Special Session 1 : Recent Advances in Brezis-Nirenberg Problem

Organizer(s): Juncheng Wei , Yuanze Wu

Introduction: The Brezis-Nirenberg problem is a classical problem in the field of nonlinear partial differential equations (PDEs) and elliptic boundary value problems. It was introduced by Haïm Brezis and Louis Nirenberg in their seminal 1983 paper. The problem is concerned with the existence and properties of solutions to certain semilinear elliptic equations with critical nonlinearities, particularly in the context of the Sobolev embedding theorem. For over forty years, the Brezis-Nirenberg problem has a profound influence on the study of nonlinear elliptic equations, particularly those involving critical exponents. It has inspired extensive research in areas such as: Variational methods and critical point theory, Concentration-compactness principles, and Geometric PDEs and Yamabe-type problems. The problem remains a central topic in modern PDE theory and continues to be actively studied. In fact, one year before his death, Brezis gave a list of his "favorite open problems", which he described as challenges he had "raised throughout his career and has resisted so far". The first Open Problem on his list is the Brezis-Nirenberg Problem on a three-dimensional ball. The purpose of this special session is to report the most important and advanced studies on Brezis-Nirenberg Problem in last five years.

Helical vortex structures with compactly supported cross-sectional vorticity for the 3D incompressible Euler equations

Schedule: July 8 15:00-15:30 Room 311

Averkios Averkiou

University of Bath, England

Co-Author(s): Monica Musso

Abstract:

In this talk, we first revisit the vortex filament conjecture for three-dimensional incompressible Euler flows with helical symmetry and no swirl. By adapting gluing methods, we obtain the first construction of a smooth helical vortex filament in the whole space $\mathbb{R}^3$ whose cross-sectional vorticity remains compactly supported in $\mathbb{R}^2$ for all times. Building on this construction, we then investigate the leapfrogging phenomenon of helical vortex filaments, in which several interacting vortex helices with a common symmetry axis alternately overtake one another while preserving their coherent structure. This is joint work with Monica Musso.

Classification results, rigidity theorems and semilinear pdes on Riemannian manifolds: a P-Function approach

Schedule: July 8 9:00-9:30 Room 311

Giulio Ciraolo

University of Milan, Italy

Abstract:

We consider solutions to critical and sub-critical semilinear elliptic equations on complete, noncompact Riemannian manifolds and study their classification as well as the effect of their presence on the underlying manifold. When the Ricci curvature is non-negative, we prove both the classification of positive solutions to the critical equation and the rigidity for the ambient manifold. The same results are established for solutions to the Liouville equation on Riemannian surfaces. Our results are obtained via an appropriate P-function whose constancy implies the classification of both the solutions and the underlying manifold. The analysis carried out on the P-function also makes it possible to classify non-negative solutions for subcritical equations on manifolds enjoying a Sobolev inequality and satisfying an integrability condition on the negative part of the Ricci curvature. We will also present results on weighted Riemannian manifolds.

Blow-up and stability for quadratic derivative nonlinear wave equations

Schedule: July 8 15:30-16:00 Room 311

Oliver Gough

University of Bath, England

Abstract:

This talk concerns finite-time blow-up in nonlinear wave equations with quadratic derivative nonlinearities. A central question is to understand the blow-up profile and mechanism in such equations, and whether the corresponding singular solutions continue to describe the dynamics under small perturbations. I will discuss recent work on these questions.

Sharp quantitative stability estimates for the Brezis-Nirenberg problem

Schedule: July 8 14:00-14:30 Room 311

Seunghyeok Kim

Hanyang University, Korea

Co-Author(s): Haixia Chen, Juncheng Wei

Abstract:

We study quantitative stability for the classical Brezis-Nirenberg problem associated with the critical Sobolev embedding $H_0^1(\Omega) \hookrightarrow L^{\frac{2n}{n-2}}(\Omega)$ in a smooth bounded domain $\Omega \subset \mathbb{R}^n$ ($n \geq 3$). To the best of our knowledge, this is the first quantitative stability result for the Sobolev inequality on bounded domains. A key discovery of our work is the emergence of unexpected stability exponents, arising from an intricate interaction among the nonnegative solution u_0 , the lower-order term λu in the Brezis-Nirenberg equation, bubble formation, and the boundary effect of the domain. A main difficulty is to quantify this boundary effect, which makes the problem fundamentally different from the Euclidean setting and from the case of smooth closed manifolds. Our proof refines and streamlines several arguments from the existing literature, while also resolving new analytical difficulties specific to the bounded domains. This talk is based on joint work with Haixia Chen (Hanyang University, Central China Normal University) and Juncheng Wei (The Chinese University of Hong Kong).

The Brezis-Peletier conjecture for one and several bubbles: blow-up analysis in dimension three

Schedule: July 8 8:30-9:00 Room 311

Tobias König

Goethe University Frankfurt, Germany

Co-Author(s): Rupert Frank, Hynek Kovarik, Paul Laurain

Abstract:

My talk is concerned with the following question: How do sequences of positive solutions u_ε to the Brezis-Nirenberg-type equation $-\Delta u_\varepsilon + (a + \varepsilon V)u_\varepsilon = u_\varepsilon^{\frac{N+2}{N-2}}$ with Dirichlet boundary conditions on a bounded domain $\Omega \subset \mathbb{R}^N$ blow up? Brezis and Peletier (1989) conjectured that the blow-up location and speed of single-peak sequences should be universally characterized by the geometry of the domain, with explicit formulas. This was confirmed shortly afterwards by Rey (1989) and Han (1991) for the case of dimension $N \geq 4$, which is non-critical in the sense of the Brezis-Nirenberg. In critical dimension $N = 3$, an additional cancellation phenomenon makes the analysis substantially more challenging. In recent work with R. Frank (Munich) and H. Kovarik (Brescia) we overcome this difficulty and prove the Brezis-Peletier conjecture for single-peak sequences in dimension three. Subsequently with P. Laurain (Paris/Champs-sur-Marne) we develop a multi-peak analogue of the Brezis-Peletier conjecture, thus providing a complete picture of blow-up in the Brezis-Nirenberg problem at arbitrary levels of energy. In my talk I will present an overview of these results and the main proof ideas.

Multi-Bubble Analysis for the Brezis-Nirenberg Problem

Schedule: July 8 8:00-8:30 Room 311

Paul Laurain

University Gustave Eiffel, France

Co-Author(s): Tobias König

Abstract:

In their celebrated paper, Brezis and Nirenberg showed that the behavior of the Yamabe-type equation, can vary greatly depending on the data of the problem. In particular, there exists a notion of critical potential a below which no positive solution exists. We are interested in the behavior of solutions as the potential approaches the critical potential. In particular, we will see how the location and the blow-up rate of these solutions are constrained by the Robin function of the operator $\Delta + a$. This is joint work with Tobias König.

Least-energy solutions for the Brezis-Nirenberg problem in dimension 3 in the non-coercive case

Schedule: July 8 13:30-14:00 Room 311

Bruno Premoselli

Universite Libre de Bruxelles, Belgium

Co-Author(s): Hussein Cheikh Ali

Abstract:

We consider in this talk the celebrated Brezis-Nirenberg equation in the non-coercive case $\lambda > \Lambda_1$, where Λ_1 is the first eigenvalue of the Laplacian on a bounded open set of $\mathbb{R}^n$. We prove in dimension 3 the existence of least-energy sign-changing solutions under a positive mass condition. This is the first general existence result for the Brezis-Nirenberg problem in dimension 3 in the non-coercive case. We introduce for this a new non-smooth variational problem, inspired from eigenvalue-optimisation problems in conformal geometry and we show that its minimisers, when they exist, provide least-energy solutions of the Brezis-Nirenberg problem. This is joint work with H. Cheikh Ali (Universite de Lille).

Some new nodal solutions to the Yamabe equation

Schedule: July 8 14:30-15:00 Room 311

Liming Sun

Academy of mathematics and systems science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Yuanli Li, Angela Pistoia

Abstract:

We find several new nodal solutions to the Yamabe equation that are not Kelvin invariant.

Normalized solutions to Sobolev critical Schrödinger equations

Schedule: July 8 9:30-10:00 Room 311

Gianmaria Verzini

Politecnico di Milano, Italy

Co-Author(s): Dario Pierotti, Junwei Yu

Abstract:

We study the existence and multiplicity of positive solutions with prescribed L^2 -norm for the (stationary) nonlinear Schrödinger equation with Sobolev critical power nonlinearity. In the free case on the full space, the associated energy functional has a mountain pass geometry on the L^2 -sphere, which boils down, in higher dimension, to the existence of a mountain pass solution. We consider this problem, either in bounded domains (i.e., the normalized Brezis-Nirenberg problem) or in presence of a potential, wondering (i) whether a local minimum solution appears, thus providing an orbitally stable family of solitons, and (ii) if the existence of a mountain pass solution persists. This talk is based on joint works with Dario Pierotti and Junwei Yu (Politecnico di Milano).

Special Session 2 : New frontiers in the compressible mathematical fluid mechanics and thermodynamics

Organizer(s): Milan Pokorný , Eduard Feireisl

Introduction: The session is devoted to new mathematical results in the compressible fluid mechanics and thermodynamics. The expected results discussed within the session are existence theory for different models and different types of solutions (strong, weak, measure-valued), qualitative properties of these solutions as well as numerical analysis for different schemes related to these models.

Existence results for thermoviscoelastic fluid models

Schedule: July 10 16:30-17:00 Room 315

Miroslav Bulíř

Charles University, Czech Rep

Abstract:

We present theoretical results on two classes of thermodynamically consistent models for heat-conducting viscoelastic fluids: (i) rate-type models of Giesekus type, and (ii) kinetic models based on the Fokker-Planck equation for dilute polymeric solutions. For both frameworks, we establish the existence of global weak solutions under natural assumptions on initial data and demonstrate their stability properties. The analysis rigorously captures key aspects of viscoelastic and thermal behavior, including energy storage and entropy production, providing a solid foundation for the study of complex materials with coupled viscous, elastic, and thermal effects.

Weak-Strong Uniqueness and Relaxation Limit for a Navier-Stokes-Korteweg Model

Schedule: July 10 15:30-16:00 Room 315

Nilasis Chaudhuri

University of Warsaw, Poland

Co-Author(s): Christian Rohde, Florian Wendt

Abstract:

In this talk, we explore a relaxation model for a compressible fluid with capillarity effects in an isothermal setting. The model involves two parameters that control the strength of the relaxation and are expected to drive the system toward the classical compressible Navier-Stokes-Korteweg equations in an appropriate limiting regime. We introduce a notion of finite-energy weak solutions for the associated initial-boundary value problem in three spatial dimensions. Within this framework, we establish a weak-strong uniqueness result. In addition, we provide a first rigorous justification of the relaxation model by proving convergence to the target system in the relaxation limit at the level of finite-energy weak solutions.

Reverse in time blowup for compressible NSE

Schedule: July 10 14:00-14:30 Room 315

Mimi Dai

University of Illinois at Chicago, USA

Abstract:

We will discuss a construction for the compressible Navier-Stokes equations that produces solutions blowing up from the right in time. This is a different blowup phenomenon from other known blowup scenarios for the compressible Navier-Stokes equations.

Mach, Rossby and the Rayleigh-B`enard problem

Schedule: July 10 9:30-10:00 Room 315

Francesco Fanelli

Basque Center for Applied Mathematics, Spain

Abstract:

In this talk, we revisit some recent results about the dynamics of heat conducting fluids in the incompressible limit regime, under non-homogeneous boundary conditions for the temperature (a relevant situation in the context of the celebrated Rayleigh-B`enard problem). We show how the classical Oberbeck-Boussinesq system, usually identified as the target system, must be modified in this case, or even dismissed in presence of additional fast rotation effects. This talk is based on joint works with Eduard Feireisl (Czech Academy of Sciences).

On a system of equations arising in meteorology: Well-posedness and data assimilation

Schedule: July 10 13:30-14:00 Room 315

Piotr Gwiazda

Institute of Mathematics Polish Academy of Sciences, Poland

Abstract:

Data assimilation plays a crucial role in modern weather prediction, providing a systematic way to incorporate observational data into complex dynamical models. The paper addresses continuous data assimilation for a model arising as a singular limit of the three-dimensional compressible Navier-Stokes-Fourier system with rotation driven by temperature gradient. The limit system preserves the essential physical mechanisms of the original model, while exhibiting a reduced, effectively two-and-a-half-dimensional structure. This simplified framework allows for a rigorous analytical study of the data assimilation process while maintaining a direct physical connection to the full compressible model. We establish well posedness of global-in-time solutions and a compact trajectory attractor, followed by the stability and convergence results for the nudging scheme applied to the limiting system. Finally, we demonstrate how these results can be combined with a relative entropy argument to extend the assimilation framework to the full three-dimensional compressible setting, thereby establishing a rigorous connection between the reduced and physically complete models.

Dafermos entropy criterion and dissipative weak solutions of the compressible Euler equations

Schedule: July 10 8:00-8:30 Room 315

Maria Lukacova

Institute of Mathematics, University Mainz, Germany

Co-Author(s): Eduard Feireisl, Changsheng Yu

Abstract:

The dissipative solutions of the Euler equations can be obtained as a limit of suitable structure-preserving, consistent, and stable numerical schemes. If the strong solution to the above equations exists, the dissipative solutions coincide with the strong solution on its life span. Otherwise, we apply the concept of K-convergence and prove the strong convergence of the empirical means of numerical solutions to a dissipative weak solution. The latter is the expected value of the dissipative measure-valued solutions and satisfies a weak formulation of the Euler equations, modulo the Reynolds turbulent stress. In this talk, we will discuss the relationship between numerical approximations of oscillatory solutions and selection criteria, such as the Dafermos criterion, which maximises entropy production, or the optimisation of the energy defect. A series of numerical simulations will illustrate theoretical results.

Unconditional stability of equilibria in thermally driven compressible fluids

Schedule: July 10 9:00-9:30 Room 315

Yong Lyu

Nanjing University, Peoples Rep of China

Co-Author(s): Eduard Feireis, Yongzhong Sun

Abstract:

We show that small perturbations of the spatially homogeneous equilibrium of a thermally driven compressible viscous fluid are globally stable. Specifically, any weak solution of the evolutionary Navier--Stokes--Fourier system driven by thermal convection converges to an equilibrium as time goes to infinity. The main difficulty to overcome is the fact the problem does not admit any obvious Lyapunov function. The result applies, in particular, to the Rayleigh-Benard convection problem.

Stability and convergence in compressible magnetohydrodynamics

Schedule: July 10 15:00-15:30 Room 315

Hana Mizerova

Comenius University in Bratislava, Slovak Rep

Abstract:

This talk presents recent results on the analysis of the full compressible magnetohydrodynamic system with non-conservative boundary conditions, providing a rigorous bridge between analytical theory and computational practice. Dissipative measure-valued (DMV) solutions are introduced together with a DMV-strong uniqueness principle, ensuring that DMV solutions coincide with strong solutions as long as the latter exist. This stability result provides a robust foundation for numerical analysis. In particular, a structure-preserving finite volume scheme is considered, and the DMV-strong uniqueness principle is employed to prove convergence of numerical solutions to the physically relevant strong solution.

Various approaches to the issue of existence for systems of compressible flows

Schedule: July 10 8:30-9:00 Room 315

Piotr B Mucha

University of Warsaw, Poland

Abstract:

In this talk, I will discuss several currently available techniques for proving the existence of weak solutions to systems describing compressible flows. The presentation will focus on methods based on the construction of solutions, with particular emphasis on their main ideas, limitations, and the open problems that remain in the field. Special attention will be given to approaches relying on the renormalization of the continuity equation. Methods based on convex integration will not be considered. The aim of the talk is to provide a comparative overview of existing analytical frameworks and to highlight directions for future research in the mathematical theory of compressible fluid models.

Steady compressible Navier--Stokes--Fourier system with temperature dependent viscosities

Schedule: July 10 17:30-18:00 Room 315

Milan Pokorný

Charles University, Czech Rep

Co-Author(s): Ondrej Kreml, Tomasz Piasecki, Emil Skrisovsky

Abstract:

We consider the model describing the steady flow of a compressible heat conducting fluid in a bounded three-dimensional domain

$$\operatorname{div}(\varrho \mathbf{u}) = 0, \operatorname{div}(\varrho \mathbf{u} \otimes \mathbf{u}) - \operatorname{div} \mathbf{S} + \nabla p = \varrho \mathbf{f}, \operatorname{div}(\varrho E \mathbf{u}) = \varrho \mathbf{f} \cdot \mathbf{u} - \operatorname{div}(p \mathbf{u}) + \operatorname{div}(\mathbf{S} \mathbf{u}) - \operatorname{div} \mathbf{q}$$

with ϱ the density, $\mathbf{u}$ the velocity field, $\mathbf{S}$ the stress tensor (here we assume the fluid to be Newtonian with temperature dependent viscosity), p the pressure, $\mathbf{f}$ the given volume force, $\mathbf{q}$ the heat flux and the total energy $E = \frac{1}{2}|\mathbf{u}|^2 + e$ with e the internal energy. We assume the pressure law of the form $p(\varrho, \vartheta) \sim \varrho^\gamma + \varrho \vartheta$ with $\gamma > 1$ and the viscosities $\mu(\vartheta), \xi(\vartheta) \sim (1 + \vartheta)^\alpha$, $\alpha \in [0, 1]$. We show the existence of a weak or variational entropy solution for the above model with internal energy fulfilling the Gibbs relation and the heat flux fulfilling the Fourier law $\mathbf{q} \sim (1 + \vartheta)^m \nabla \vartheta$ with ϑ the temperature, $m = m(\gamma, \alpha) > 0$. We first review the results for the case $\alpha = 1$ which has been known before. Then we show extensions for $\alpha \frac{3}{2}$ both for Dirichlet and Navier boundary conditions for the velocity and Robin and Dirichlet boundary conditions for the temperature. Finally we briefly touch the situation when $\gamma \leq \frac{3}{2}$, here only for Robin boundary conditions for the temperature. The solutions are constructed for arbitrarily large sufficiently integrable data.

The hydrostatic Lagrangian approach to the compressible primitive equations

Schedule: July 10 17:00-17:30 Room 315

Arnab Roy

Basque Center for Applied Mathematics (BCAM), Spain

Co-Author(s): Matthias Hieber, Yoshiki Iida and Tarek Z\{o\}chling

Abstract:

In this talk, we explain the hydrostatic Lagrangian approach to the compressible primitive equations. A fundamental aspect in the analysis is the investigation of the compressible hydrostatic Lam\`{e} and Stokes operators. Local strong well-posedness for large data and global strong well-posedness for small data are established under various assumptions on the pressure law, both in the presence and absence of gravity.

A finite element method for the incompressible Euler system

Schedule: July 10 14:30-15:00 Room 315

Bangwei She

Capital Normal University, Peoples Rep of China

Co-Author(s): M^aria Luk^vc^{ov}-Medvid^{ov}

Abstract:

We study the stability and convergence of a RT_k/P_k finite element method for the incompressible Euler system. Moreover, we extend the error analysis result of Guzm^an et al. [H(div) conforming and DG methods for incompressible Euler equations, IMA J. Numer. Anal. 37(4)1733-1771, 2017] to the case of $k=0$.

Unconditional stability of radially symmetric steady states of compressible viscous fluids with inflow/ outflow boundary conditions

Schedule: July 10 10:30-11:00 Room 315

Agnieszka Swierczewska-Gwiazda

University of Warsaw, Poland

Abstract:

We show that certain radially symmetric steady states of compressible viscous fluids in domains with inflow/outflow boundary conditions are unconditionally stable. This means that any not necessarily radially symmetric solution of the associated evolutionary problem converges to a single radially symmetric steady state.

Incompressible limits at large Mach number for a reduced compressible MHD system

Schedule: July 10 11:30-12:00 Room 315

Aneta Wr^{oblewska-Kami}nska

Institute of Mathematics, Polish Academy of Sciences, Poland

Abstract:

In this talk we will present a singular limit problem for a reduced model for compressible non-resistive MHD. This system can also be related to a certain class of two-fluid models. By a suitable rescaling of the magnetic pressure in terms of some parameter $\varepsilon > 0$, by letting $\varepsilon \rightarrow 0$ we perform the incompressible limit while keeping the Mach number of order $O(1)$. Our study is conducted in the framework of global in time finite energy weak solutions and for ill-prepared initial data. We also consider a similar problem in presence of a strong Coriolis term. The key ingredient of the proof, based on a compensated compactness argument, is the use of the transport equation (well-known in the context of two-fluid models) underlying the dynamics. Thanks to it, and differently from previous studies about the incompressible limit, we are able to identify the asymptotic of the terms of order $O(\varepsilon)$ and to characterise their dynamics; such an information is in fact crucial to obtain a closed system in the limit. This is recent joint result with Francesco Fanelli and Young-Sam Kwon.

temperature-driven turbulence in compressible fluid flows

Schedule: July 10 12:00-12:30 Room 315

Yuhuan Yuan

Nanjing University of Aeronautics and Astronautics, Peoples Rep of China

Abstract:

We study the long-time behaviour of the temperature-driven compressible flows. We show that numerical solutions of a structure-preserving finite volume method generate a discrete attractor that consists of entire discrete trajectories. Further, we prove the convergence of discrete attractors to their continuous counterparts. Theoretical results are illustrated by extensive numerical simulations of the well-known Rayleigh-Benard problem. The numerical results also indicate the validity of the ergodic hypothesis and imply that a non-zero Reynolds stress persist for long time. Finally, we also observe that any invariant measure is of Gaussian type in sharp contrast with the conjecture proposed by [Glimm et al., SN Applied Sciences, 2:paper no.2160, 2020].

Relative entropy method and applications for the compressible two-fluid flows

Schedule: July 10 9:00-9:30 Room 315

Ewelina Zatorska

University of Warwick, England

Co-Author(s): Yang Li, Maria Lukacova-Medvidova, Milan Pokorny

Abstract:

I will present a model of compressible two viscous fluids flow with a common velocity field and algebraic closure for the pressure law. The constitutive relation involves densities of both fluids through an implicit function. The existence of global-in-time finite energy weak solutions to this system is known since the work of Novotný and Pokorný [Arch. Rational Mech. Anal., 2020]. On the other hand, existence of local-in-time strong solutions is due to Piasecki and Zatorska [J. Math Fluid Mech., 2022]. In this talk I will focus on the weak--strong uniqueness principle using the relative entropy method. In sharp contrast to the two-phase model of Baer-Nunziato type, the volume fraction of one of phases obeys a transport equation with an additional nonlinear term. This gives rise to troublesome terms in the relative entropy inequality. We are able to close the estimate by making an elaborate use of the structure of the system.

Special Session 3 : Analysis of diffuse and sharp interface models

Organizer(s): Alain Miranville , Andrea Giorgini , Maurizio Grasselli

Introduction: Numerous significant real-world phenomena are characterized by the evolution of interfaces separating distinct chemical species, such as the behavior of multi-phase fluids, intracellular phase separation, tumor growth dynamics, image reconstruction (inpainting), and self-assembly processes in diblock copolymers. The classical description of moving interfaces is called Sharp Interface (SI) theory. The interface separating the phase boundary is assumed to be an evolving in time surface with zero thickness. This formulation leads to free-boundary problems. A more recent approach instead treats the interface as a narrow region with finite thickness. This is the so-called Diffuse Interface (DI) theory. In the latter case, the evolution of the interface is described as the level set of the fluid concentration (called phase-field), which is uniform in bulk phases and varies steeply but continuously across the interface. Over the past few decades, there has been remarkable activity in both the theoretical analysis and numerical simulations of SI and DI models. This session aims to spotlight recent advancements in these fields and possibly related free boundary problems, providing a platform for experts in the field and emerging researchers to share their cutting-edge techniques, innovative perspectives, and future goals.

On a nonisothermal tumor growth model of Caginalp type

Schedule: July 6 17:30-18:00 Room 428

Giulia Cavalleri

WIAS, Germany

Co-Author(s): Pierluigi Colli, Elisabetta Rocca

Abstract:

We study a nonisothermal phase-field system of Caginalp type that describes tumor growth under thermal therapy. The model couples a possibly viscous Cahn–Hilliard equation, governing the evolution of the healthy and tumor phases, with an equation for the heat balance, and a reaction-diffusion equation for the nutrient concentration. The resulting nonlinear system incorporates chemotaxis and active transport effects, and hyperthermia appears as a control variable. First, we prove well-posedness for the initial-boundary value problem and additional regularity. Then, we define a suitable cost functional and show the existence of optimal controls. Finally, we analyze the differentiability of the control-to-state operator and establish necessary first-order conditions of optimality. These results have been obtained in collaboration with Pierluigi Colli (University of Pavia) and Elisabetta Rocca (University of Pavia).

On the Cahn-Hilliard equation with nonlinear diffusion: the non-convex case

Schedule: July 6 16:30-17:00 Room 428

Monica Conti

Politecnico di Milano, Italy

Co-Author(s): Stefania Gatti, Andrea Giorgini and Giulio Schimperna

Abstract:

We investigate the Cahn-Hilliard equation with nonlinear diffusion and non-degenerate mobility modeling phase separation phenomena in complex systems (e.g., crystals and polymers). Previous results in the literature on this model relied on the strong convexity assumption of the gradient part of the energy, which excludes relevant cases. In this work, we remove the convexity condition and establish new qualitative properties of solutions under general assumptions on the diffusion and mobility functions.

POINTWISE TRACKING OPTIMAL CONTROL PROBLEM FOR CAHN-HILLIARD NAVIER-STOKES SYSTEM

Schedule: July 7 15:30-16:00 Room 428

Sheetal Dr DHARMATTI

Indian Institute of Science Education and Research Thiruvananthapuram, India

Co-Author(s): Greeshma K

Abstract:

We study a pointwise tracking optimal control problem for the two-dimensional local Cahn Hilliard Navier Stokes system, which models the evolution of two immiscible, incompressible fluids. The source term in the Cahn Hilliard equation acts as a control, and the cost functional measures the deviation of the phase variable from desired values at a finite set of spatial points over time. This setting reflects realistic applications where only a limited number of sensors are available. We also study a variant of the above pointwise tracking control problem where the cost is incorporated with a terminal time pointwise tracking term. The main mathematical difficulty arises from the low regularity of the cost functional due to the pointwise evaluation of the state variables. We prove the existence of strong solutions, establish the existence of an optimal control, and the differentiability of the control-to-state mapping. We define the adjoint system using a transposition method to characterise optimal control. Moreover, a first order necessary optimality condition is derived in terms of the adjoint for both problems. Furthermore, we prove that our analysis can be extended to the case of singular potentials.

Deterministic particle approximation of a fourth-order PDE

Schedule: July 6 14:30-15:00 Room 428

Charles Elbar

Universite Claude Bernard Lyon 1, France

Co-Author(s): Alejandro Fernandez-Jimenez

Abstract:

Many partial differential equations describe how a macroscopic density of particles/cells evolves in time. So, it is a natural question to ask whether there is a microscopic (deterministic) model that leads to a given macroscopic PDE. For second-order aggregation-diffusion equations, this connection has been proved, starting with the porous medium equation in 2001. In this work, we extend that framework to a fourth-order equation, inspired by applications in cell-cell adhesion in biological systems. This is a joint work with Alejandro Fernandez-Jimenez.

Asymptotic analysis of Robin type transmission problems for gap junctions

Schedule: July 6 15:30-16:00 Room 428

Takeshi Fukao

Ryukoku University, Japan

Co-Author(s): Takeshi Fukao

Abstract:

In this talk, we focus on Robin type transmission conditions that describe gap junctions arising in biology, and we study the well-posedness of transmission problems of Allen--Cahn type as well as the asymptotic analysis with respect to the permeability parameter. For parabolic equations, transmission problems with Dirichlet--Neumann type conditions have been widely studied. Here, we treat Robin type transmission conditions instead. A distinctive feature of these conditions is that they allow discontinuity in the values of the unknown functions on the interface shared by the two domains. This can be well understood by recalling that, in the Dirichlet--Neumann case, the trace condition ensures continuity of values across the interface. The Robin type condition naturally expresses the degree of interaction on the interface in terms of the permeability. We first establish the well-posedness of the Robin type problem as a prerequisite. For this purpose, the abstract theory of evolution equations governed by subdifferential operators is applicable. We then discuss the limiting procedures when the permeability converges to zero and when it diverges to infinity. It can be shown that the former limit yields a split system consisting of separate Allen--Cahn equations on each domain, while the latter limit leads to a transmission problem of Dirichlet--Neumann type, both results being consistent with the physical meaning of the permeability. Furthermore, we address the case where the permeability depends on time, as well as the case where the permeability diverges to infinity at a finite time, showing that the system can be extended beyond that instant.

A Generalized Cahn-Hilliard equation with non-degenerate mobility: Well Posedness and Convergence to the Classical Cahn-Hilliard

Schedule: July 6 15:00-15:30 Room 428

Pietro Galimberti

University of Ferrara, Italy

Co-Author(s): Monica Conti, Pietro Galimberti, Stefania Gatti and Andrea Giorgini

Abstract:

We study a generalized Cahn--Hilliard equation, based on an unconstrained theory proposed by Duda, Sarmiento and Fried in 2021, with non-degenerate mobility and nonlinear terms of logarithmic type. We prove well posedness of weak solutions, propagation of regularity and a type of separation from the pure states property for weak solutions, also in three space dimensions. Moreover, given that this model can be interpreted as a perturbation of the classical Cahn-Hilliard, we prove convergence of weak solutions to weak solutions of the Cahn-Hilliard equation on finite time intervals.

Diffuse interface models on evolving surfaces: Modeling and analysis

Schedule: July 6 13:30-14:00 Room 428

Harald Garcke

Department for Mathematics, Germany

Abstract:

We consider geometric evolution problems consisting of evolution equations for a closed hypersurface coupled to parabolic equations on this evolving surface. More precisely, the evolution of the hypersurface is determined by a geometric flow that depends on a quantity defined on the surface via a diffusion equation. This system arises as a gradient flow of an energy functional. Assuming suitable parabolicity conditions, we derive short-time existence for the system. The proof is based on a linearization and contraction argument. Afterwards, several properties of the solution are analyzed. In particular, we emphasize to what extent the surface in our setting evolves in the same way as under the usual mean curvature flow. To this end, we show that the surface area is strictly decreasing but we give an example of a surface that exists for infinite times nevertheless. Moreover, mean convexity is conserved whereas convexity is not. We will also discuss how Willmore type flow can be coupled to the Cahn-Hilliard equation on an evolving surface. The resulting system is a coupled Cahn-Hilliard/Canham-Helfrich flow. Finally, we construct an embedded hypersurface that develops a self-intersection over time and we discuss how solutions can be computed numerically with the help of an evolving surface finite element discretization.

Recent advances on the 2D Cahn-Hilliard equation with nondegenerate mobility

Schedule: July 7 9:30-10:00 Room 428

Stefania Gatti

Universita' degli Studi di Modena e Reggio Emilia, Italy

Co-Author(s): Monica Conti, Pietro Galimberti, Andrea Giorgini

Abstract:

In this talk, we will discuss some recent results on the 2D Cahn-Hilliard equation with nondegenerate concentration-dependent mobility and logarithmic potential. More precisely, we proved that any weak solution is unique, exhibits propagation of uniform-in-time regularity, and stabilizes towards an equilibrium state of the Ginzburg-Landau free energy for large times. These results improve the state of the art dating back to a work by Barrett and Blowey and were obtained in a joint work with Monica Conti, Pietro Galimberti and Andrea Giorgini.

Estimates on free-boundary propagation for solutions to stochastic porous-media equations

Schedule: July 7 13:30-14:00 Room 428

Guenther Gruen

Department of Mathematics, University of Erlangen-Nuremberg, Germany

Co-Author(s): Joshua Utley

Abstract:

We study the impact of noise on the expected propagation in time of the boundary of the spatial support of solutions to stochastic porous-media equations with non-linear conservative noise, i.e. multiplicative noise inside a convective term. Starting from a recent result together with M. Sauerbrey on finite speed of propagation for kinetic solutions of such equations (for which existence and non-negativity is known due to previous work of B. Fehrman and B. Gess), we formulate upper estimates on propagation rates for small times. With respect to scaling, these estimates coincide with the estimates known to be optimal in the deterministic setting. For large times, however, we observe a scaling transition in the stochastic case which gives strong indication that the presence of conservative noise terms enhances spreading significantly. For the proof, we rely on integral estimates and appropriate filtering techniques. This is a joint work with Joshua Utley, Friedrich-Alexander University Erlangen - Nuremberg.

Nonlocal-to-Local Convergence of the Cahn--Hilliard Equation and its Operator

Schedule: July 7 14:30-15:00 Room 428

Christoph Hurm

University of Regensburg, Germany

Co-Author(s): Helmut Abels, Patrik Knopf

Abstract:

We prove convergence of a sequence of weak solutions to the nonlocal Cahn-Hilliard equation to the weak solution to the corresponding local Cahn-Hilliard equation. The analysis is done in the case of sufficiently smooth bounded domains with Neumann boundary condition and a $W^{1,1}$ -kernel. The proof is based on an energy method. Additionally, we prove the strong L^p -convergence of the nonlocal operator to a local differential operator together with a rate of convergence. The analysis also includes more singular kernels.

Two-phase flows with bulk-surface interaction in an evolving domain

Schedule: July 7 9:00-9:30 Room 428

Patrik Knopf

University of Regensburg, Germany

Co-Author(s): Yadong Liu

Abstract:

We discuss a thermodynamically consistent model, which describes the time evolution of a two-phase flow in an evolving domain. The movement of the free boundary of the domain is driven by the velocity field of the mixture in the bulk, which is determined by a Navier--Stokes equation. In order to take interactions between bulk and boundary into account, we further consider two materials on the boundary, which may be the same or different materials as those in the bulk. The bulk and the surface materials are represented by respective phase-fields, whose time evolution is described by a bulk-surface convective Cahn--Hilliard equation. This approach allows for a transfer of material between bulk and surface as well as variable contact angles between the diffuse interface in the bulk and the boundary of the domain. To provide a more accurate description of the corresponding contact line motion, we include a generalized Navier slip boundary condition on the velocity field. Based on local mass balance laws, we derive our model from scratch in two different ways: by the Lagrange Multiplier Approach and (in the case of matched densities and no mass flux between bulk and surface) by the Energetic Variational Approach. We further show that our model generalizes previous models from the literature, which can be recovered from our system by either dropping the dynamic boundary conditions or assuming a static boundary of the domain.

Finite-dimensional attractors to 2D NSE-Allen-Cahn equations with irregular potentials

Schedule: July 6 17:00-17:30 Room 428

Dalibor Prazak

Charles University, Faculty of Mathematics and Physics, Czech Rep

Abstract:

We consider 2D Navier-Stokes system coupled to Allen-Cahn equation with irregular potentials. This leads to a differential inclusion with maximal monotone term. Existence of finite-dimensional attractor is shown using the method of Γ -trajectories, where the key step is an L^1 -estimate of the difference of discontinuous terms.

Velocity control in Navier-Stokes-Cahn-Hilliard models with curvature effects

Schedule: July 7 8:30-9:00 Room 428

Andrea Signori

Politecnico di Milano, Italy

Abstract:

In this talk, I discuss a class of coupled partial differential equation systems describing the interaction between an incompressible viscous fluid and a deformable membrane modeled through a phase-field variable. The analysis is carried out within the Navier-Stokes framework, allowing for the description of physically relevant regimes arising in biological membranes and amphiphilic materials. Particular attention is devoted to an associated optimal control problem in two spatial dimensions. The results highlight the interplay between fluid flow and membrane curvature in driving phase evolution and shaping membrane morphology. This work is part of a joint project with Prof. Hao Wu (Fudan University, Shanghai).

Two-phase flows with bulk-surface interaction: A Navier--Stokes--Cahn--Hilliard model with dynamic boundary conditions

Schedule: July 7 14:00-14:30 Room 428

Jonas Stange

University of Regensburg, Germany

Co-Author(s): Patrik Knopf

Abstract:

We present a new diffuse interface model for incompressible, viscous fluid mixtures with bulk-surface interaction. This system consists of a Navier--Stokes--Cahn--Hilliard model in the bulk that is coupled to a surface Navier--Stokes--Cahn--Hilliard model on the boundary. Compared with previous models in the literature, the inclusion of an additional surface Navier--Stokes equation is motivated, for example, by biological applications. We prove the existence of weak solutions by means of a semi-Galerkin scheme combined with a fixed-point argument. To discretize the Navier--Stokes subsystem, we analyze a novel bulk-surface Stokes system and its corresponding bulk-surface Stokes operator, whose eigenfunctions serve as a natural basis to approximate the velocity fields. This is joint work with Patrik Knopf (University of Regensburg)

Structure and Stability of Global Attractors for a Cahn-Hilliard Tumor Growth Model

Schedule: July 7 15:00-15:30 Room 428

Sema Yayla

Hacettepe University, Turkey

Abstract:

In this talk, we study the long-time dynamics of a Cahn-Hilliard tumor growth model with chemotaxis, focusing on the structure and stability of its global attractors. Using a Łojasiewicz-Simon type inequality, we analyze the asymptotic behavior of trajectories and show that solutions converge to stationary states. This allows us to describe the geometric structure of the global attractor in terms of stationary solutions. We also investigate the stability of the attractor with respect to perturbations of the chemotaxis parameter and establish continuity properties of the attractors under suitable assumptions.

Global solutions of nematic liquid crystal flow

Schedule: July 6 14:00-14:30 Room 428

Yong Yu

The Chinese University of Hong Kong, Hong Kong

Co-Author(s): Yuan Chen, Soojum Kim, Shun Li, Pei Lyu

Abstract:

Ericksen-Leslie hydrodynamical system describes the motion of nematic liquid crystal molecules. Lin-Liu model is a simplified Ericksen-Leslie model which preserves the main structure of the original Ericksen-Leslie system. In this talk, I survey several results concerning about the global weak solutions to the Lin-Liu model, and the long-time asymptotic behaviors of these solutions. The problems to be addressed will be on both 2D and 3D, and on both domains with fixed boundary and free boundary. All the results presented in the talk are supported by RGC grants of Hong Kong.

Special Session 4 : Mathematical methods in electromagnetism and related topics

Organizer(s): Ioannis Stratis , Pier Domenico Lamberti

Introduction: The proposed session will mainly focus on various mathematical aspects of electromagnetism and Maxwell's equations, as well as related problems, from modeling issues to well-posedness results. Various constitutive laws will be presented, linear and nonlinear, local and non-local. The domains considered will vary from very regular to Lipschitz and to fractal. The relevant function spaces will be considered, with an emphasis on boundary and topological conditions. Basic and advanced tools to solve problems of electromagnetism in their natural functional frameworks will be taken into consideration, and mathematical methods (e.g., boundary integral methods, semigroups, functional and variational methods, etc.) will be employed. As examples of applications of these tools and concepts, several fundamental problems of electromagnetism, stationary or time-dependent, will be considered: scattering of an incident wave by obstacles, bounded or not; wave propagation in waveguides; homogenization problems; optimization problems. Suitable numerical methods will of course be also considered. Mathematical notions allow a better understanding of modelization in electromagnetism and emphasize the essential features related to the geometry and nature of materials.

Lipschitz stable determination of polyhedral conductivity inclusions from local boundary measurements

Schedule: July 7 17:30-18:00 Room 315

Andrea Aspri

Università degli Studi di Milano Statale, Italy

Co-Author(s): Elena Beretta, Elisa Francini, Sergio Vessella

Abstract:

In this talk, we investigate the nonlinear inverse problem of recovering a polyhedral inclusion in a three-dimensional homogeneous isotropic conducting body from boundary measurements. We consider the conductivity equation and establish a Lipschitz stability estimate for polyhedral conductivity inclusions, measured in the Hausdorff distance, in terms of the local Dirichlet-to-Neumann map. As a byproduct, we derive a uniqueness result that is new in this general framework. This is joint work with Elena Beretta (NYU Abu Dhabi), Elisa Francini, and Sergio Vessella (University of Florence).

Averaged Steklov eigenvalues and applications to electromagnetic imaging problems

Schedule: July 7 18:00-18:30 Room 315

Mayeul Chavanne

Institut Polytechnique de Paris, France

Co-Author(s): Lorenzo Audibert, Houssem Haddar

Abstract:

We study electromagnetic inverse scattering problems at fixed frequency using multi-static data. Classical imaging methods typically fail when the background medium is highly oscillatory. To overcome this limitation, we propose a new method based on the introduction of artificial resonators. The inverse problem considered here takes as input measurements of scattered waves recorded at large distances from an object, known as the far-field pattern, at a fixed frequency. The goal is to recover information about the internal composition of the probed domain. The general structure of the proposed algorithm is as follows:

- \begin{itemize} \item At a point z in the investigated domain Ω , we numerically introduce an artificial resonator D_z .
- \item We define in D_z an artificial spectral problem with a unique resonance eigenvalue λ , and relate this resonance to a quantitative indicator function $I(z)$.
- \item The resonance parameter is identified from the far field data using the Inside-Outside Duality method, or the Linear Sampling Method.
- \item The indicator function $I(z)$ is computed by sweeping z over the inspected area.

\end{itemize}

Homogenization of partial differential equations with quasiperiodic coefficients

Schedule: July 7 8:30-9:00 Room 315

Elena Cherkaev

University of Utah, USA

Abstract:

Quasiperiodic geometry is characterized by a long-range order in the absence of periodicity. Quasiperiodic structures can be modeled using the cut-and-projection method that restricts or projects a periodic function in a higher dimensional space to a lower dimensional subspace cut at an irrational projection angle. We derive the homogenized equations for the effective electromagnetic properties of a quasiperiodic composite using cut-and-projection method applied to periodic homogenization in a higher dimensional space. We use equations for the local cell problem in the higher dimensional space established in the homogenization process to develop the Herglotz analytic representation for the effective properties of quasiperiodic materials. This integral representation determines the spectral characteristics of fields in quasicrystalline composites and can be used to derive bounds for the effective properties. A joint work with Niklas Wellander and Sebastien Guenneau.

Nonclassical dynamics transmission problems of generalized thermo-electro-magneto-elasticity

Schedule: July 6 16:30-17:00 Room 315

Otar Chkadua

Andrea Razmadze Mathematical Institute of I. Javakhishvili Tbilisi State University, Sokhumi State University, Rep of Georgia

Co-Author(s): Otar Chkadua

Abstract:

We investigate the solvability, asymptotic analysis and regularity results of solutions to three-dimensional nonclassical dynamics problems of interaction between thermo-elastic and generalized thermo-electro-magneto-elastic homogeneous anisotropic bodies with a crack at the interface. The considered generalized thermo-electro-magneto-elasticity model is based on the Green--Lindsay theory. Unlike classical theories of thermo--elasticity, heat propagation in this model occurs with a finite speed. Using the Laplace transform, potential theory and the method of pseudodifferential equations on a manifold with a boundary based on the Wiener--Hopf factorization method, existence and uniqueness theorems are proved. Asymptotics of solutions near the edge of a interface crack and near the lines where the boundary conditions of different types meet are obtained. Based on the asymptotic analysis, we establish almost optimal $H^{\frac{1}{2}}$ results for solutions. This is joint work with D. Natroshvili and T. Buchukuri. This research was supported by Shota Rustaveli National Science Foundation (SRNSF) Grant No. FR-23-267.

The Neumann-Poincaré spectrum, shape analyticity and shape derivatives

Schedule: July 6 17:00-17:30 Room 315

Matteo Dalla Riva

University of Padova, Italy

Co-Author(s): Pier Domenico Lamberti, Paolo Luzzini, and Paolo Musolino

Abstract:

A small metallic particle exposed to electromagnetic radiation with wavelength much larger than its size exhibits shape-dependent resonant frequencies, a phenomenon known as surface plasmon resonance. In the quasi-static regime, this effect is described by a Laplace transmission problem, which can be reformulated as an eigenvalue problem for the Neumann--Poincaré (NP) operator, a boundary integral operator associated with the harmonic double-layer potential. In this talk, based on recent work (arXiv:2504.00696), I will discuss how the NP eigenvalues depend on smooth deformations of the domain. In particular, we will see that simple eigenvalues, as well as symmetric functions of multiple eigenvalues, depend real-analytically on the shape. We will also describe explicit formulas for their first shape derivatives and discuss some further consequences of these results.

The spectrum of dissipative Maxwell operators

Schedule: July 7 14:00-14:30 Room 315

Francesco Ferrareso

University of Verona, Italy

Co-Author(s): S. Bogli, M. Marletta, L. Provenzano, C. Tretter.

Abstract:

The Maxwell system (1865) in time-harmonic formulation has always an infinite dimensional kernel (given by gradient fields), even in bounded domains; therefore, the Maxwell essential spectrum is always non-empty, and many standard spectral theory techniques fail. Even more dramatically, dissipative Maxwell systems in bounded domains might have segments of essential spectrum along the imaginary axis. If the L^∞ coefficients ϵ , μ , and σ are asymptotically constant, I will show that the essential spectrum of the Maxwell system in anisotropic conductive media with perfectly conducting boundary conditions can be characterised as the union of the essential spectra of a bounded operator and of an unbounded selfadjoint curlcurl operator. I will further discuss how we can concretely compute the spectrum of the original Maxwell system avoiding spectral pollution phenomena. I will conclude with some results aimed at relating the geometry of the domain Ω with the spectrum of the curlcurl operator. Based on joint work with S. Bogli (Durham), M. Marletta (Cardiff), L. Provenzano (Sapienza Rome) and C. Tretter (Bern).

Stability estimates for inverse boundary value problems

Schedule: July 7 17:00-17:30 Room 315

Elisa Francini

Università di Firenze, Italy

Co-Author(s): Elena Beretta, Sergio Vessella

Abstract:

Inverse boundary value problems need strong a priori assumptions to ensure a good rate of stability. We consider the inverse conductivity problem in the case of piecewise constant conductivities defined on a known partition of the domain. While the general problem is severely ill-posed, exhibiting logarithmic stability, the introduction of structural a priori information allows for stronger stability results. We prove Lipschitz stability of the map from the conductivity to the Dirichlet-to-Neumann operator within this class. The analysis relies on the finite-dimensional structure of the parameter space together with quantitative unique continuation and propagation of smallness arguments.

Integrable Reductions and Solitons of Nonlocal NLS Systems

Schedule: July 6 14:30-15:00 Room 315

Dimitrios J. Frantzeskakis

Department of Physics, National and Kapodistrian University of Athens, Greece

Co-Author(s): T. P. Horikis and G. N. Koutsokostas

Abstract:

In recent years, considerable attention has been devoted to nonlinear systems featuring a spatially nonlocal nonlinear response. In such systems, the nonlinear response at a point in space depends on the field values in a surrounding region. Here, we study nonlocal nonlinear Schrödinger (NLS) models describing the evolution of optical beams in thermal optical media, nematic liquid crystals, and plasmas. We use multiscale expansion methods to asymptotically reduce the nonlocal NLS to completely integrable models arising in the theory of water waves, such as the Korteweg--de Vries (KdV), the Boussinesq/Benney--Luke, the Kadomtsev--Petviashvili (KP-I and KP-II), the Davey--Stewartson (DS-I and DS-II), and the Melnikov systems. We show that the strength of nonlocality plays a role analogous to surface tension and thus strongly affects the types of solitons that can form in nonlocal media, as well as their stability and interactions.

Towards a universal approach for the boundary problems

Schedule: July 6 15:00-15:30 Room 315

NIKOLAOS GIALELIS

National and Kapodistrian University of Athens, Greece

Abstract:

We discuss a new universal technique for dealing with boundary value problems, both static and evolutionary, which is independent of the respective geometry, and present some applications.

Modal bases of coaxial electromagnetic step index fibers

Schedule: July 7 14:30-15:00 Room 315

Martin Halla

Karlsruhe Institute of Technology, Germany

Abstract:

We consider the eigenvalue problem to find the modes of an electromagnetic coaxial step index fiber. More specific, we consider a closed (meaning PEC boundary conditions) cylindrical waveguide with circular cross section Γ , wave propagation modeled by the time-harmonic Maxwell's equations with frequency ω , the permeability μ and the permittivity ϵ being scalar, uniformly positive, piece-wise constant and depending only on the radial variable of the cross section. We prove that if the deviation from the homogeneous case is small, i.e.,

$\|\delta_\epsilon, \delta_\mu\| := \|\epsilon - \epsilon_0\|_{L^\infty} + \|\mu - \mu_0\|_{L^\infty} \ll 1$, then the tangential electric (magnetic) fields of the modes form a Riesz basis in $\mathbf{H}_0(\text{curl}\Gamma; \Gamma)$ ($\mathbf{H}(\text{curl}\Gamma; \Gamma)$). For a constant permeability (permittivity) the Riesz basis

property for the tangential electric (magnetic) fields holds also in the natural trace space $\mathbf{H}_0^{-1/2}(\text{curl}\Gamma; \Gamma)$ ($\mathbf{H}^{-1/2}(\text{curl}\Gamma; \Gamma)$). These results hold also for complex frequencies ω . In addition, if $\omega \in \mathbb{R}$, then for small enough $\delta_{\epsilon, \mu}$ all wavenumbers are located on the axes and there exist no backward modes. Key tools in the analysis are a particular reformulation of the eigenvalue problem, the perturbation theory for selfadjoint operators under a local subordinate condition and uniform properties of Bessel functions. [1] Modal bases of coaxial electromagnetic step index fibers, M. Halla, arXiv:2603.16716

Autoencoder-based global concave optimization for Electrical Impedance Tomography

Schedule: July 7 16:30-17:00 Room 315

Bastian Harrach

Goethe University Frankfurt, Germany

Abstract:

We aim to derive globally convergent reconstruction algorithms for the inverse coefficient problem of Electrical Impedance Tomography (aka the famous Calderón problem) and its application in lung imaging. Our main tool is to reformulate the problem as a concave semidefinite minimization problem. This allows to construct a globally convergent EIT reconstruction algorithm that is computationally feasible for a moderately low number of unknowns. We then combine this approach with the recent data-driven observation that realistic lung images lie on a nonlinear manifold that is much lower dimensional than the space of all possible images. Variational autoencoder techniques can be used to learn such a low-dimensional parametrization, but a standard out-of-the-box autoencoder would destroy the concavity properties of the reconstruction problem. Hence, we show how to adjust the autoencoder training process in such a way that concavity (and thus global convergence of the final reconstruction strategy) is preserved.

The domain derivative for the reconstruction of the shape of obstacles in nonlinear scattering problems

Schedule: July 6 17:30-18:00 Room 315

Frank Hettlich

Karlsruhe Institute of Technology / Institute for Applied and Numerical Mathematics, Germany

Co-Author(s): Frank Hettlich

Abstract:

The reconstruction of the shape of scattering objects from the knowledge of the far field pattern of scattered electromagnetic waves is a challenging problem in inverse scattering theory. Several approaches to such severely ill-posed problems are discussed in the past in case of linear scattering models. But for scattering objects given by nonlinear media or nonlinear boundary conditions much less is known. As a recent contribution we discuss the dependence of scattered waves on perturbations of the shape of such scattering object. This leads to a shape derivative, the so called domain derivative, of solutions of the underlying partial differential equations. We show existence and certain characterizations of these derivatives in case of nonlinear boundary value problems. Additionally, based on the given characterization of the domain derivative an all-at-once Newton-type regularization method is suggested for solving the inverse reconstruction problem in case of far field data from just one incident field. The numerical performance of such a scheme is illustrated by some numerical examples.

Wave propagation in a waveguide filled with hyperbolic media

Schedule: July 7 13:30-14:00 Room 315

Maryna Kachanovska

POEMS, INRIA, France

Co-Author(s): Dylan Machado

Abstract:

We study wave propagation in a waveguide with local geometric perturbations filled with a cold, strongly magnetized plasma, modeled by the 2D Maxwell equations with a current term. The corresponding frequency-domain model reduces to a Helmholtz equation with frequency-dependent coefficients, namely
$$\begin{aligned} & \partial_y^2 u + (1 - \frac{\omega_p^2}{\omega^2}) u = 0, \\ & \partial_x^2 u + \omega^2 u = 0, \end{aligned}$$
 where $\omega > 0$ is a given frequency and $\omega_p > 0$ is the plasma frequency. The main difficulty stems from the fact that the principal symbol of the underlying operator becomes hyperbolic for frequencies not exceeding the plasma frequency. Our goal is to understand the behavior of the viscosity limits of this problem. We prove a limiting absorption principle for a class of geometric perturbations, based on the behavior of the Dirichlet-to-Neumann operators and on techniques used in the analysis of time-dependent problems. Next, we give a meaning to a time-harmonic problem that is reminiscent of the wave equation with boundary conditions at the initial and final times. If time permits, we discuss the construction of the numerical methods used to simulate this type of problem, in particular perfectly matched layers.

Nonvariational solutions of boundary value problems for the Helmholtz equation in multiply connected domains

Schedule: July 6 14:00-14:30 Room 315

Massimo Lanza de Cristoforis

Dipartimento di Matematica 'Tullio Levi-Civita', Italy

Abstract:

We consider a possibly multiply connected bounded open subset Ω of $\mathbb{R}^n$ of class $C^{1,\alpha}$, $\alpha \in]0, 1[$ and we plan to solve classical boundary value problems for the Helmholtz equation in Ω and in the exterior of Ω in terms of acoustic layer potentials. The main focus of the talk is on α -Hölder continuous solutions which may not have a classical normal derivative at the boundary points of Ω and that may have an infinite Dirichlet integral around the boundary of Ω . Namely for solutions that do not belong to the classical variational setting.

Maxwell's Equations and its Real Relatives

Schedule: July 6 13:30-14:00 Room 315

Rainer Picard

TU Dresden, Institute for Analysis, Germany

Co-Author(s): Rainer Picard, Sascha Trostorff, Marcus Waurick

Abstract:

We recall the concept of evo-systems and illustrate their utility for unifying different fields in mathematical physics and engineering. The Maxwell system and its (possibly surprising) relatives are a particular topic of interest. We shall be discussing various classical systems of partial differential equations of classical mathematical physics emphasizing a setup in a real Hilbert space setting. As a byproduct the common perception that modern physics appears to be entangled with complex numbers will turn out to be slightly misleading.

Extremal problems for symmetric functions of the first three Maxwell eigenvalues

Schedule: July 6 18:00-18:30 Room 315

Rebecca Sempio

Universit`a di Padova, Italy

Co-Author(s): Pier Domenico Lamberti, Luigi Provenzano

Abstract:

It is known that the Faber-Krahn inequality does not hold for Maxwell eigenvalues: regardless of whether a volume or a perimeter constraint is imposed, the ball does not minimize the first eigenvalue. Notably, the first eigenvalue in the ball has multiplicity three. Motivated by this observation, as well as by a criticality result established by P.D. Lamberti and M. Zaccaron in 2021, we investigate symmetric functions of the first three Maxwell eigenvalues and discuss their potential minimization properties under suitable geometric constraints. This work is based on a joint collaboration with Pier Domenico Lamberti and Luigi Provenzano.

Perturbation of an electrostatic potential by a biaxially anisotropic cylinder

Schedule: July 7 15:00-15:30 Room 315

Eric Stachura

Kennesaw State University, USA

Co-Author(s): Akhlesh Lakhtakia

Abstract:

We study the boundary-value problem for the perturbation of an electrostatic potential by an infinitely long, homogeneous, biaxially anisotropic dielectric cylinder in vacuum. An affine coordinate transformation is used to convert the problem for the internal potential into one into the standard Laplace equation, and inversion of this transformation provides a series representation for the internal potential. We obtain explicit formulas for a uniaxial dielectric cylinder with distinguished axis either parallel or perpendicular to the cylinder axis. Numerical results show that the methodology is stable even for very high degrees of anisotropy and that the degree of anisotropy of the cylinder affects the spatial variations of the potential in both the external and internal regions. This is joint work with A. Lakhtakia (Penn State).

Foldy-Lax T-matrix schemes in direct and inverse multiple scattering

Schedule: July 7 18:30-19:00 Room 315

Nikolaos L. Tsitsas

Aristotle University of Thessaloniki, Greece

Co-Author(s): Andreas Kalogeropoulos and Nikolaos L. Tsitsas

Abstract:

The Foldy-Lax method is a robust technique for solving direct multiple scattering problems. In this work, by combining the T-Matrix approach and the Sommerfeld's decomposition method, we modify the Foldy-Lax method to solve inverse scattering problems related to the spherical-wave excitation of a dielectric medium surrounded by a cluster of point-like PEC scatterers. Combining the Foldy-Lax method with the recently established Overall Superposition Method, the multiple scattering problem is reduced to a problem of a single scatterer excited by an ensemble of dipoles. In this way, schemes for the determination of the unknown fields of the point-like scatterers are devised by means of the T-Matrix approach. The energy transfer process, the behavior of the involved energy and flux and the performance of the proposed schemes are analyzed numerically.

Bending and twisting of electromagnetic waveguides

Schedule: July 7 15:30-16:00 Room 315

Michele Zaccaron

ENSTA Paris, France

Co-Author(s): Philippe Briet, Maxence Cassier, Thomas Ourmières-Bonafos

Abstract:

Consider a reference homogeneous and isotropic electromagnetic waveguide with a simply connected cross-section embedded in a perfect conductor. In this setting, when the waveguide is straight, the spectrum of the associated self-adjoint Maxwell operator with a constant twist (which may be zero) is entirely essential, lies on the real line and is symmetric with respect to zero, exhibiting a gap around the origin. In this talk, we present new results on the effects of the geometric deformations of bending and twisting on the spectrum of the Maxwell operator. More precisely, we provide, on the one hand, sufficient conditions on the asymptotic behaviour of the curvature and twist of a perturbed waveguide ensuring the preservation of the essential spectrum. Our approach relies on a Birman-Schwinger-type principle which has an interest of its own. On the other hand, we give sufficient conditions, involving in particular the shape of the cross-section, so that the geometrical deformation creates discrete spectrum within the gap, and give some insight into its localization. Finally, we show some theoretical and numerical results further investigating the sufficient condition involving the geometry of the cross-section.

Homogenization and 3D-2D dimension reduction of a functional on manifold valued functional spaces.

Schedule: July 7 9:00-9:30 Room 315

Elvira Zappale

Department of Basic and Applied Sciences for Engineering, Sapienza - University of Rome, Italy

Co-Author(s): Michela Eleuteri, Luca Lussardi, Andrea Torricelli and Joseph Dongo, Joel Fotso Tachago, Frank Tchinda

Abstract:

Simultaneous dimensional reduction and homogenization is rigorously obtained for integral functionals defined on the manifold constrained Orlicz-Sobolev and BV spaces. The results find application in the study of equilibria for liquid crystals, in ferromagnetism or for magnetostrictive materials where the order parameters take their values into a given manifold.

Dismantling Dimensional Barriers: The Sliced Spectral Framework for Periodic Elliptic Operators

Schedule: July 7 9:30-10:00 Room 315

Ruming Zhang

Technical University of Berlin, Germany

Co-Author(s): Ruming Zhang

Abstract:

The study of the limiting absorption principle for elliptic equations with periodic structures is very challenging when the dimension is greater than one. The fundamental obstacle lies in the mismatch between directional physical reality and the direction-independent classic spectral analysis, resulting in intricate geometry of band structures and Fermi surfaces in high dimensions. In this talk, we introduce the novel Sliced Spectral Analysis (SSA) framework which introduce the direction into classic spectral analysis. It dismantles the geometrical complexities by reducing the problems to its analytical essence on the one-dimensional slices. With the new SSA framework, the solution can be formulated in a semi-analytic form, which not only gives an explicit representation, but also reflects the phenomenon in physics. The new SSA approach resolves the mismatch between mathematics and physics, and also breaks the dimensional barriers. It also opens a door to a lot of further possibilities, ranging from the analysis of solutions and numerical simulations for the solutions.

Special Session 5 : New trends in pattern formations and dynamics for dissipative systems and related topics

Organizer(s): Junping Shi , Danielle Hilhorst , Yoshihisa Morita

Introduction: Many biological and physical phenomena can be described by mathematical models with a dissipative structure. These include nonlinear reaction-diffusion systems, particle systems or kinetic equations approximating reaction-diffusion systems, and other partial differential equation models, nonlocal evolution models and functional differential equation models. In this session, we will bring together recent studies on solutions of various dissipative dynamical systems related to spatial-temporal pattern formation, propagation dynamics, and symmetry breaking bifurcations, presenting new aspects of solutions capturing nonlinear phenomena together with underlying solution structures.

Interplay Between Starvation-Driven Diffusion and Diverse Interspecific Competition in Heterogeneous Environments

Schedule: July 7 16:30-17:00 Room 313

Inkyung Ahn

Korea University, Korea

Co-Author(s): Youngseok Chang, Wonhyung Choi

Abstract:

This study examines competition models based on the Lotka--Volterra form that incorporate starvation-driven diffusions (SDD). Such dispersal assumes that species adjust their dispersal according to the abundance or scarcity of resources in a heterogeneous habitat. The primary objective of this study is to examine how SDD, in combination with diverse interspecific interactions, affects species' fitness and coexistence states. To this end, the study introduces a refined classification for competing interactions based on a novel metric that quantifies the variability of resource heterogeneity across the environment. This approach contrasts with traditional models that assume uniform diffusion within homogeneous environments. The study reveals that the interplay between species' dispersal strategies and the varying intensities of interspecific competition significantly impacts ecological outcomes.

Sturm Oscillation Theory for Nonlocal Diffusion Equations

Schedule: July 6 13:30-14:00 Room 313

Peter Bates

Michigan State University, USA

Co-Author(s): Guangyu Zhao

Abstract:

In its simplest form, Sturm's comparison result is: Theorem. Let $q_1(x) \leq q_2(x)$ and not identically equal on $[a, b]$. Let u satisfy $u'' + q_1(x)u = 0$ on $[a, b]$, and v satisfy $v'' + q_2(x)v = 0$ on $[a, b]$. Suppose that $a < b$ are consecutive zeros of u . Then v has at least one zero in (a, b) . There is a discrete version for symmetric tri-diagonal operators with positive off-diagonal terms. However, it does not hold for general symmetric penta-diagonal operators with positive off-diagonal terms. The main point today, is to replace the second derivative operator by a bounded integral operator, resulting in a nonlocal diffusion-like operator. Is there a similar comparison theorem? First, when u'' is replaced by

$$Lu := \int J(x - y)[u(y) - u(x)]dy,$$

where $J \geq 0$ is continuous, even, with compact support and $J(0) > 0$. Then with a scaled version in $\mathbb{R}^n$

$$L_\epsilon u := \int_\Omega \frac{1}{\epsilon^{n+2}} J\left(\frac{x-y}{\epsilon}\right)[u(y) - u(x)]dy,$$

for $\epsilon > 0$ and small, and where $\Omega \subset \mathbb{R}^n$ is smoothly bounded, and $J \geq 0$ is radially symmetric with $f(0) > 0$. This operator converges, in some sense, to a multiple of the Laplacian, as $\epsilon \rightarrow 0$. Does a Sturm-like comparison theorem hold when ϵ is small? This is joint work with Guangyu Zhao.

Pattern formation and dynamics in spatially structured epidemic models

Schedule: July 6 16:30-17:00 Room 313

Pierluigi Colli

University of Pavia, Italy

Abstract:

Compartmental models are widely used in the mathematical description of infectious disease spread. When spatial heterogeneity is taken into account, these models naturally lead to systems of reaction-diffusion equations with dissipative structure. In this talk, we present some recent results, obtained in collaboration with co-authors, on spatially structured epidemic models in heterogeneous environments. Particular attention is devoted to models incorporating modified chemotaxis-type mechanisms, which account for population movement driven by spatial gradients of infection. Such effects can generate nontrivial spatial patterns and complex dynamical behaviors. We discuss analytical results including well-posedness and qualitative properties of solutions, with emphasis on the interplay between diffusion, aggregation mechanisms, and nonlinear reactions. Finally, we highlight connections with optimal control problems and asymptotic limits.

Self-similar fast-reaction limits of reaction-diffusion systems with nonlinear diffusion

Schedule: July 6 15:00-15:30 Room 313

Elaine Crooks

Swansea University, Wales

Co-Author(s): Yini Du

Abstract:

This talk is concerned with the characterisation of fast-reaction limits of systems with nonlinear diffusion, when there are either two reaction-diffusion equations or one reaction-diffusion equation and one ordinary differential equation, on unbounded domains. The ideas used extend previous results in the linear diffusion case and show that in the fast-reaction limit, spatial segregation leads to the two components of the original systems each converging to the positive and negative parts of a self-similar limit profile that satisfies one of four ordinary-differential systems. The position of the free boundary separating where such self-similar profiles are positive from where they are negative provides information on the rate of penetration of one substance into the other and for specific forms of nonlinear diffusion, some results will be presented on the relationship between the form of the nonlinear diffusion and the position of this free boundary. This is joint work with Yini Du.

Hybrid bifurcations: Periodicity from Eliminating a Line of Equilibria

Schedule: July 6 17:30-18:00 Room 313

Jia-Yuan Dai

National Tsing Hua University, Taiwan

Co-Author(s): Alejandro Lpez-Nieto, Phillip Lappicy, Nicola Vassena, Hannes Stuke, Jia-Yuan Dai

Abstract:

We describe a new mechanism that triggers periodic orbits in smooth dynamical systems. To this end, we introduce the concept of hybrid bifurcations, which consists of a bifurcation without parameters and a classical bifurcation. Our main result classifies the hybrid bifurcation when a line of equilibria with an exchange point of normal stability vanishes. We showcase the efficacy of our approach by proving stable periodic coexistent solutions in an ecosystem of two competing predators with Holling's type II functional response.

On the data assimilation problem for models of compressible fluids

Schedule: July 7 13:30-14:00 Room 313

Eduard Feireisl

Institute of Mathematics, Czech Academy of Sciences, Czech Rep

Abstract:

We present some new results concerning the continuous data assimilation problems for models of compressible fluids. Our main hypothesis is that the observed solution is regular (bounded) while the synchronized solution very weak (the so called dissipative measure valued solution). The method applies to both viscous and inviscid fluids

Pattern formation in Lotka-Volterra competition systems on two-dimensional domains

Schedule: July 6 17:00-17:30 Room 313

Hirofumi Izuhara

University of Miyazaki, Japan

Co-Author(s): Hirofumi Izuhara

Abstract:

In this talk, we study a Lotka--Volterra competition system with diffusion. It is well known that this system exhibits segregation patterns when the parameters lie in the bistable regime and the domain is nonconvex, for example, dumbbell-shaped. However, it remains unclear how such segregation patterns emerge as a two-dimensional domain deforms from convex to nonconvex. We reveal the structure of stationary solutions in the bistable regime with the aid of numerical computations.

Kinetic equations with spatial turning frequency and their diffusion limits

Schedule: July 7 15:00-15:30 Room 313

Seungmin Kang

National Center for Theoretical Sciences (NCTS), Korea

Co-Author(s): Yong Jung Kim

Abstract:

We introduce a kinetic model for diffusion in spatially heterogeneous environments, arising for instance from variations in temperature or the surrounding medium, and to identify the macroscopic diffusion equation described by this kinetic dynamics. While most existing studies formulate kinetic models using a turning frequency (or turning rate) measured per unit time, we instead consider a model in which the turning frequency is measured per unit traveled distance. Our goal is to clarify how this spatially defined turning mechanism differs analytically from the standard temporal one, and how the resulting diffusion equation differs from diffusion limits derived from classical kinetic equations.

Diffusive Limit of a Discrete Persistent Kinetic Model with Heterogeneity and Anisotropy

Schedule: July 6 15:30-16:00 Room 313

Min-Yoo Kim

KAIST, Korea

Abstract:

Persistent random walks exhibit the distinctive feature that fractionation occurs only when both heterogeneity and anisotropy are present. In this talk, we consider a discrete kinetic model derived from such a system, consisting of four linear inhomogeneous equations on a two-dimensional torus. We establish the existence and uniqueness of a weak solution, together with an energy-type inequality. We then show that as a small parameter tends to zero, the sum of the four components of the solution converges to the solution of a parabolic initial value problem governed by a heterogeneous diffusion equation, thereby providing a rigorous connection between the kinetic model and macroscopic fractionation phenomena. This is joint work with Danielle Hilhorst and Ho-Youn Kim

ON HOT SPOTS CONJECTURE FOR DOMAIN WITH N-AXES OF SYMMETRY

Schedule: July 6 14:00-14:30 Room 313

Yi Li

John Jay College of Criminal Justice, CUNY, USA

Co-Author(s): Dr. Hongbin Chen

Abstract:

In this talk, we will discuss the hot spots conjecture for n-axes symmetric domain in R^n by continuity method. More precisely, we show that the odd Neumann eigenfunctions with lowest nonzero eigenvalues are the Morse functions on the boundary that have exactly two non-degenerate critical points and the eigenfunctions are monotone in the direction from minimum point to maximum point. As a consequence, we show that hot spots conjecture holds for such kind of domains provided that the second Neumann eigenvalue is simple. And we also settle the Jerison and Naridashvili's conjecture for the domains with n-axes of symmetry or hyperbolic drum. Finally, associated with odd Neumann eigenfunctions we obtain a sharp estimate for nonzero least Neumann eigenvalue.

Exact solutions describing very slow layer oscillations in a shadow reaction-diffusion system

Schedule: July 6 14:30-15:00 Room 313

Yasuhito Miyamoto

The University of Tokyo, Japan

Co-Author(s): Shin-ichiro Ei, Tatsuki Mori

Abstract:

We show in a rigorous way that a stable internal single-layer stationary solution is destabilized by the Hopf bifurcation as the time constant exceeds a certain critical value. Moreover, the exact critical value and the exact period of oscillatory solutions can be obtained. The exact period indicates that the oscillation is very slow, i.e., the period is of order $O(e^{C/e})$. We also rigorously prove that Hopf bifurcations from multi-layer stationary solutions occur. In this case anti-phase horizontal oscillations of layers are shown by formal calculations. Numerical experiments show that the exact period agrees with the numerical period of a nearly periodic solution near the Hopf bifurcation point. Anti-phase (out of phase) horizontal oscillations of layers are numerically observed.

On a reaction-diffusion model for the self-propelled motion of a rigid body

Schedule: July 7 17:00-17:30 Room 313

Masaharu Nagayama

Hokkaido University, Japan

Co-Author(s): Masaharu Nagayama, Natsume Motohashi, Ken-Ichi Nakamura, Koya Sakakibara, Keisuke Takasao, Satoshi Nakata

Abstract:

Although many mathematical models of self-propelled motion have been proposed, they are typically constructed for specific types of objects, resulting in separate formulations for different target systems. To date, no mathematical model has been established that can uniformly describe self-propelled motion across a wide range of systems, from solid objects to liquid droplets. As a first step toward a comprehensive theoretical understanding of self-propelled motion, it is therefore essential to formulate a unified set of equations capable of describing such phenomena. In this study, we propose a mathematical model that could describe self-propelled motion from liquid droplets to solid objects within a single framework. The proposed model consists of a coupled system of a phase-field equation, derived from the L2 gradient-flow structure, and a concentration-field equation. This formulation enables the description of deformable droplet motion as well as circular solid-like motion. Furthermore, by introducing a spatially inhomogeneous function into the potential term, the model can reproduce self-propelled motions with more complex shapes, such as elliptical and dumbbell-like structures. In this presentation, we investigate solid-like motions observed in the proposed model through numerical simulations and compare the results with those of previous studies and experimental observations.

Propagation speed of bistable traveling waves in a 3-component Lotka-Volterra competition-diffusion system

Schedule: July 6 18:00-18:30 Room 313

Ken-Ichi Nakamura

Meiji University, Japan

Co-Author(s): Toshiko Ogiwara

Abstract:

This study investigates the propagation speed of bistable traveling waves in a three-component Lotka-Volterra reaction-diffusion system. First, we consider a case where competition between two of the species is absent, enabling the application of the comparison principle. By constructing suitable super- and sub-solutions, we establish sufficient conditions to determine the sign of the wave speed. Furthermore, we discuss the sign of the speed in a system that lacks the comparison principle, specifically focusing on cases where the competition coefficients between the two species are sufficiently small.

On the equilibrium solutions for bistable reaction-diffusion equations on a star-shaped metric graph

Schedule: July 7 14:30-15:00 Room 313

Toshiko Ogiwara

Josai University, Japan

Abstract:

This talk concerns a bistable reaction-diffusion equation with McKean-type nonlinearity on a bounded or unbounded star-shaped metric graph. Among other things, we study the existence and nonexistence, as well as the multiplicity, of equilibrium solutions with monotone profiles. We also investigate how the structure of the set of such equilibrium solutions changes depending on whether the graph is bounded or unbounded.

Global in time weak solutions to a Navier-Stokes/Mullins-Sekerka system

Schedule: July 7 17:30-18:00 Room 313

Andrea Poiatti

University of Parma, Italy

Co-Author(s): Helmut Abels

Abstract:

In this talk, I would like to introduce a model for the flow of two incompressible, viscous and immiscible fluids in a bounded domain, with different densities and viscosities. This model consists of a coupled system of Navier-Stokes and Mullins-Sekerka type parts, and can be obtained from the asymptotic limit of the diffuse interface model introduced by Abels, Garcke, and Grün in 2012. I will introduce a new notion of weak solutions and prove its global in time existence, together with a consistency result. This new notion of solution allows to include the case of different densities of the fluids, a sharp De Giorgi energy dissipation principle, as well as a weak formulation of the constant contact angle condition at the boundary, which were left open in the previous notion of solution proposed by Abels and Röger in 2009.

Bifurcations in Nonlocal Aggregation-Diffusion Systems

Schedule: July 6 18:30-19:00 Room 313

Yurij Salmaniw

University of Sheffield, England

Abstract:

In this talk, I will present recent analytical and numerical results on bifurcation structure and pattern formation in nonlocal aggregation-diffusion systems on the torus. The first part, based on joint work with J. A. Carrillo, focuses on a two-species aggregation-diffusion model, in which we study long-time behaviour, stability, and local bifurcations from spatially homogeneous states. The second part concerns joint work with J. A. Carrillo and A. L. Villares on numerical stationary states for nonlocal Fokker-Planck equations. There, a semi-analytical fixed-point framework allows one to compute nontrivial stationary solutions directly and efficiently explore their bifurcation diagrams. Finally, I will discuss recent progress on an aggregation-diffusion model with nonlinear sensing, in collaboration with S. Raible, in which the local theory is extended to settings with stronger nonlinear effects and, in some regimes, higher-dimensional kernels of the linearised operator. Together, these works highlight the complementary roles of analytical bifurcation theory and semi-analytical computation in revealing rich families of stationary patterns in dissipative nonlocal systems.

Spatial-temporal dynamics of a nonlocal advection-diffusion model with time delay

Schedule: July 7 14:00-14:30 Room 313

Chuncheng Wang

Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Xuanyu Liu; Dejun Fan

Abstract:

Nonlocal advection and time delay play important roles on the movement of macroscopic and microscopic substances. In this paper, we study a nonlocal advection-diffusion model with time delay being involved in the advection term. For the proposed model, the compactness of solution operators and global boundedness of solutions are proved. Based on these results, we further investigate the local dynamics near the positive steady state, when the kernel is taken as a triangular function. The results show that the sign and magnitude of the mean of kernel will cause Hopf bifurcation and bifurcation switches, while it has been shown in the literature that the positive steady state is always stable for symmetric kernel, such as top-hat function. Finally, we construct a Lyapunov functional to show the global asymptotic stability of the steady state, when the advection coefficient is less than a critical value.

Special Session 6 : Propagation dynamics of PDEs: recent progress and trends

Organizer(s): Yihong Du , Jian Fang , Wenjie Ni

Introduction: Propagation dynamics has been successfully captured by partial differential equations since the pioneering works of Fisher and Kolmogorov-Petrovski-Piskunov (KPP) in the 1930s. Significant further developments have appeared in the last a few decades, including models incorporating heterogeneous environments, nonlocal dispersal, climate change and evolution of range boundaries. This special session aims to showcase some of the recent progresses in this direction by speakers from a selection of the main players in the field, which will provide an opportunity for exchange of ideas and fostering collaborations, and hopefully help to identify several promising directions of research in this area for the next 5-10 years.

Spreading in a shifting environment: linear and nonlinear features

Schedule: July 7 14:00-14:30 Room 628

Thomas Giletti

University Clermont-Auvergne, France

Abstract:

In this talk, we will discuss the large time behavior of solutions of reaction-diffusion equations and systems with shifting heterogeneities. Such a situation arises in the modeling of population dynamics under an environmental change, due e.g. to global warming. We will be concerned with the extinction or survival of species, and in the latter case in how it spreads ahead of the heterogeneity. While the key issue is whether the species is able to outpace the climate, which may sound relatively straightforward, we will find the picture may quickly become more intricate than expected. In particular, we will see how nonlinear features may strongly impact the outcome due for instance to Allee effects or inter-species competition. In particular, we will see that the size of the initial population may play a crucial part into its survival at large times.

Spreading dynamics for the Lotka-Volterra system with general initial supports: the strong competition

Schedule: July 7 14:30-15:00 Room 628

Hongjun Guo

Tongji University, Peoples Rep of China

Abstract:

This talk concerns the spreading dynamics of a high-dimensional strong competition Lotka-Volterra system where two species initially occupy disjoint measurable (possibly unbounded) subsets in $\mathbb{R}^N$, which are called initial support. Recently, Hamel and Rossi introduced some new geometric notions, such as bounded or unbounded directions and positive-distance interior, for single-species equations with general initial supports. Under these notions and appropriate assumptions, we characterize directional spreading behavior for the two-species system: precise spreading speeds and sets for both species are derived.

Reaction-diffusion equations in $\mathbb{R}^N$: convergence to fronts

Schedule: July 7 8:00-8:30 Room 628

Francois Hamel

Aix-Marseille University, France

Co-Author(s): Hongjun Guo and Luca Rossi

Abstract:

This talk is concerned with reaction-diffusion-advection equations in homogeneous or spatially periodic media. I will discuss the asymptotic properties of the solutions of the Cauchy problem, under an assumption of weak stability of the constant steady states 0 and 1, or for Fisher-KPP reactions. I will especially show that front profiles appear, along sequences of times and points, in the large-time dynamics of the solutions, whether their initial supports be bounded or unbounded. I will also discuss further geometrical properties of the asymptotic invasion shapes of invading solutions. The talk is based on some joint works with Hongjun Guo and Luca Rossi.

Propagation dynamics of a nonautonomous epidemic system with nonlocal diffusion

Schedule: July 7 9:30-10:00 Room 628

Zhucheng Jin

University of Science and Technology of China, Peoples Rep of China

Abstract:

In this talk, we investigate the spreading speeds and generalized traveling wave solutions for a nonautonomous epidemic system with nonlocal dispersal. The main challenge arises from the lack of a comparison principle for such nonmonotone systems. To characterize the spreading speed of the system, we first establish the spreading speed of a scalar nonautonomous KPP equation. Then, using a derived key pointwise estimate, we compare the solution of the system with that of the scalar KPP equation and thus obtain the spreading speed of the system. Combining with the spreading speed results, we demonstrate the nonexistence of generalized traveling wave solutions with small wave speeds in average sense. By constructing proper super and sub solutions, we establish the existence of generalized traveling wave solutions and study the limiting behavior of the wave profile using the uniform persistence theory. This talk is based on a joint work with Prof. Xiongxiang Bao.

Spreading speeds of diffusive age-structured equations in slowly and rapidly varying media

Schedule: July 7 15:30-16:00 Room 628

Hao Kang

Tianjin University, Peoples Rep of China

Co-Author(s): Shuang Liu

Abstract:

We investigate the effects of the spatial period in determining the spreading speed of age-structured reaction-diffusion equations in spatially periodic media. We establish the asymptotic behavior of the spreading speed when the spatial period tends to zero and infinity, respectively. By comparing the spreading properties between the age-structured models and the classic Fisher-KPP reaction-diffusion equations, we show that the introduction of the age structure leads to more complicated spreading dynamics. Specifically, in rapidly oscillating media, there does not exist a definitive relationship between their spreading speeds. In contrast, in slowly oscillating media, the two spreading speeds coincide and can be characterized by a family of periodic Hamilton-Jacobi equations, with the zero order term determined by an age-structured equation parameterized by the spatial variable. Finally, we present an explicit formula for the limiting spreading speed in patchy environments, via constructing the viscosity solutions of the associated Hamilton-Jacobi equation. This is a joint work with Shuang Liu in BIT.

Free boundary problems for the spread of ecosystem engineers

Schedule: July 7 17:00-17:30 Room 628

Frithjof Lutscher

University of Ottawa, Canada

Abstract:

Propagation dynamics describing the spread of invasive species are historically studies on static landscapes. Many such species, however, alter the landscape through which they spread in order to improve conditions for their own survival. Such species are referred to as ``ecosystem engineers``. To describe the propagation dynamics for such species, we have to include the interactions between the species and the landscape, which makes the landscape dynamic. We formulate a two-sided free boundary problem for the spread of ecosystem engineers. We study the existence and uniqueness of traveling waves for this system under different assumptions of the population dynamics (monostable or bistable) and different scenarios for the movement condition of the free boundary. We discover a large range of qualitatively different profiles of traveling waves under different parameter regimes.

Dynamics of Curves under the Anisotropic Area-Preserving Curvature Flow

Schedule: July 7 16:30-17:00 Room 628

Hirokazu Ninomiya

Meiji University, Japan

Co-Author(s): Harunori Monobe

Abstract:

The area-preserving curvature flow was first studied by Gage in 1986. He proved that any smooth closed planar curve evolving under this flow exists for all time and converges to a circle enclosing the same area. A natural question is how the dynamics change when the coefficients depend on the anisotropy. In this talk, we study the anisotropic area-preserving curvature flow for planar curves, where both the external forcing term and the coefficient of the curvature may exhibit anisotropy depending on the orientation of the curve. Under suitable assumptions on the anisotropic coefficients, we prove the uniqueness of traveling wave solutions. Moreover, we show that any closed convex curve evolving under the flow converges to this traveling wave solution.

Infinite cascade of traveling waves in a nonlocal model of gravitational fingering

Schedule: July 7 15:00-15:30 Room 628

Iuliia Petrova

University of Sao Paulo (USP), Brazil

Co-Author(s): Sergey Tikhomirov

Abstract:

We introduce a new nonlocal model for gravitational fingering and study its wave propagation dynamics. Gravitational fingering is an instability in the displacement of miscible fluids in porous media, governed by Darcy's law, which occurs when a lighter fluid lies below a heavier one and gravity drives an exchange of positions. Our main result establishes the existence of a propagating terrace consisting of infinitely many traveling waves in a semi-discrete Transverse Flow Equilibrium (TFE) model. The talk is based on ongoing joint work with Sergey Tikhomirov (PUC-Rio, Brazil) and extends earlier results on two-tubes models of gravitational fingering (SIMA, arxiv:2401.05981)

Front propagation dynamics in Fisher-KPP equations on unbounded metric graphs

Schedule: July 7 8:30-9:00 Room 628

Wenxian Shen

Auburn University, USA

Co-Author(s): Hewan Shemtaga, Selim Sukhtaiev

Abstract:

This talk is concerned with front propagation dynamics in Fisher-KPP equations on unbounded metric graphs. Such equations can be used to model the evolution of populations living in environments with network structure. There are several studies on front propagation phenomenon in bistable equations on unbounded metric graphs. It is known that, in such equations, the network structure of the underlying environment may block the propagation of the fronts. It will be shown in this talk that the network structure of the environments does not block the propagation of the fronts in Fisher-KPP equations. In particular, it will be shown that the Fisher-KPP equation on an unbounded graph with finite many edges has the same spreading speed c^* as the Fisher KPP equation on the real line $\mathbb{R}$ and has a generalized traveling wave connecting the stable positive constant solution and the trivial solution with averaged speed c for any $c > c^*$.

Polyhedral entire solutions in reaction-diffusion equations

Schedule: July 7 18:00-18:30 Room 628

Masaharu Taniguchi

Okayama University, Japan

Abstract:

We study polyhedral entire solutions to a bistable reaction-diffusion equation in $\mathbb{R}^n$. We consider a pyramidal traveling front solution to the same equation in $\mathbb{R}^{n+1}$. As the speed goes to infinity, its projection converges to an n -dimensional polyhedral entire solution. Conversely, as the time goes to $-\infty$, an n -dimensional polyhedral entire solution gives n -dimensional pyramidal traveling front solutions. The result in this paper suggests a correlation between traveling front solutions and entire solutions in general reaction-diffusion equations or systems.

Propagation for heterogeneous reaction-diffusion equations on adjacent domains

Schedule: July 7 9:00-9:30 Room 628

Andrea Tellini

Universidad Politécnica de Madrid, Spain

Co-Author(s): Henri Berestycki, Luca Rossi

Abstract:

We consider a system of two Fisher-KPP-type reaction-diffusion equations formulated on adjacent domains, with different diffusion coefficients and reaction parameters. The two equations are coupled via a transmission condition at their common boundary. We will show how these heterogeneities influence the global behavior of the system, focusing in particular on the asymptotic speed of propagation. These results are based on a joint work with Henri Berestycki (EHESS - Paris) and Luca Rossi (Sapienza University - Rome).

Stability of traveling wave solutions for the singular Keller-Segel model with logistic source

Schedule: July 7 17:30-18:00 Room 628

Zhian Wang

The Hong Kong Polytechnic University, Hong Kong

Co-Author(s): Jingyu Li

Abstract:

The classical singular Keller-Segel system with logistic growth has been shown to admit a unique traveling wave solution (up to a translation) with a minimal (critical) wave speed, yet the stability of this solution remains unproven. In contrast, in the absence of logistic growth, the system has a unique traveling wave solution with a single and well-defined wave speed whose stability has been well established in the literature. This study establishes the nonlinear stability of traveling wave solutions for the singular Keller-Segel system with logistic growth, covering both critical and supercritical wave speed scenarios. To our knowledge, this work marks the first stability result concerning traveling wave solutions of chemotaxis-growth systems. We prove our stability result by following three steps. First, we derive several novel auxiliary results regarding the traveling wave solutions that are indispensable for subsequent stability analysis. Next, by leveraging the anti-weighted function technique, we identify appropriate weight functions needed in our stability analysis. Finally, by employing the weighted energy method and conducting sophisticated coupling estimates, we show that the unique traveling wave solution is nonlinearly asymptotically stable under small perturbations.

Propagation dynamics of reaction and diffusion equations in a time-heterogeneous shifting environment

Schedule: July 7 18:30-19:00 Room 628

Xiaoqiang Zhao

Memorial University of Newfoundland, Canada

Co-Author(s): Lei Zhang and Xiao-Qiang Zhao

Abstract:

In this talk, I will first give a brief review of the propagation dynamics of evolution equations in a shifting environment. Then I will report our recent research on a large class of time and space heterogeneous reaction-diffusion equations. We obtain the leftward and rightward spreading speeds in terms of the shifting speed and the spreading speed of an associated limiting equation. We also establish the existence, uniqueness and nonexistence of the forced traveling wave, and further apply this result to obtain the existence of almost periodic traveling waves for nonautonomous SIS epidemic models.

Special Session 7 : Recent developments on nonlinear geometric PDEs

Organizer(s): Angela Pistoia , Pierpaolo Esposito , Giusi Vaira , Isabella Ianni

Introduction: The applications of partial differential equations (PDEs) to a wide variety of geometry related problems arising in both pure mathematics and applied sciences have been largely studied in the past years. The aim of this section is to present recent progress in PDEs from geometric perspectives and to bring together researchers who are interested in this field.

Maximum principle for higher order operators and applications to nonlinear PDEs

Schedule: July 6 13:30-14:00 Room 618

Daniele Cassani

University of Insubria & RISM, Italy

Abstract:

It is well known how the Maximum Principle (MP) in general fails to hold for uniformly elliptic operators of order higher than two, even in smooth convex domains. In D. Cassani and A. Tarsia (2022) it was shown in dimension two and three, by establishing a new Harnack type inequality with nonlocal remainder terms, that the validity of the positivity preserving property can be restored when lower order derivatives are taken into account as a perturbation of the higher order differential operator. We will present further advances in this direction, extending the validity of the MP to any dimension and fairly general domains. Moreover, we will discuss how the presence of inertial terms affects the range of the perturbation parameter, providing a balance between the positivity restoring effect of lower order derivatives and the mass energy. Applications to semilinear biharmonic equations are presented.

Ground States and Nodal Solutions for the Mean Curvature Operator in Minkowski Space

Schedule: July 6 17:30-18:00 Room 618

Francesca Colasuonno

Università degli Studi di Torino, Italy

Abstract:

The Dirichlet problem for the mean curvature operator in Minkowski space is considered in a radial domain of $\mathbb{R}^N$. For this problem, we prove the existence of a ground state and a linking solution in the general case, and the multiplicity of radial nodal solutions in the radially symmetric setting. We also investigate the asymptotic behavior of these solutions as a parameter in the equation tends to infinity.

New ancient solutions to the Yamabe flow on the sphere

Schedule: July 6 17:00-17:30 Room 618

Seunghyeok Kim

Hanyang University, Korea

Co-Author(s): Haixia Chen, Monica Musso

Abstract:

The Yamabe flow is a geometric evolution equation that aims to improve the geometry of a manifold by deforming its metric toward one with constant scalar curvature. In this talk, I will introduce the historical background for the Yamabe flow and then discuss recent developments concerning ancient solutions, namely, solutions that exist for all negative times. In the latter part of the talk, I will present joint work with Dr. Haixia Chen (Hanyang University, Central China Normal University) and Prof. Monica Musso (University of Bath) on the existence of non-rotationally symmetric ancient solutions.

Eigenfunctions in domains with small balls removed

Schedule: July 6 18:00-18:30 Room 618

Ying Li

Central China Normal University & Sapienza University of Rome, Peoples Rep of China

Co-Author(s): Laura Abatangelo, Massimo Grossi

Abstract:

This work concentrates on the eigenvalues and eigenfunctions of the Dirichlet Laplacian in a bounded domain with a small hole $B(P, \varepsilon)$ removed. We derive pointwise estimates of the u -capacity potential V_ε associated with $B(P, \varepsilon)$ in dimensions two and higher. Using these estimates, we obtain a uniform estimate for $u_\varepsilon - u - V_\varepsilon$ when the eigenvalue is simple. When the eigenvalue is multiple, we also derive the bifurcation of λ_ε , which was previously obtained by Abatangelo, L'ena and Musolino in 2022 and 2024. Finally, in dimension two, we apply the uniform estimate of u_ε to study the number of intersection points between the nodal line $\mathcal{N}_\varepsilon$ and $\partial B(P, \varepsilon)$.

Extremising eigenvalues of the GJMS operators in a fixed conformal class

Schedule: July 6 14:00-14:30 Room 618

Bruno Premoselli

Universite Libre de Bruxelles, Belgium

Co-Author(s): Emmanuel Humbert and Romain Petrides

Abstract:

Let (M, g) be a closed Riemannian manifold of dimension $n \geq 3$ and P_g be a conformally-covariant operator on (M, g) . We consider in this talk two problems at the crossroads of conformal geometry and spectral theory: 1) determining the extremal value that the renormalized eigenvalues of P_g take as g runs through a fixed conformal class and 2) determining whether these extremal values are attained at an extremal metric. Examples of such operators P_g include the famous conformal Laplacian of the Yamabe problem, $P_g = \Delta_g + c_n S_g$, but also its higher-order generalisations of even order. Extremal metrics for these problems, when they exist, are not smooth in general, and yield interesting geometric objects, such as (singular) harmonic maps into large-dimensional spheres or least-energy possibly nodal solutions of prescribed Q -curvature type problems. Addressing these questions requires to investigate renormalized eigenvalues functionals that are highly non-smooth. We develop an ad hoc variational theory to study them: we obtain in particular semi-continuity results and we provide an explicit Euler-Lagrange equation for local extremals. As a consequence we obtain new existence results for extremals by performing a bubble-tree analysis of suitable extremizing sequences. This is joint work with E. Humbert (Universite de Tours) and R. Petrides (Universite Paris Cite) and is based on arXiv:2505.08280.

Minimization of the first eigenvalue of the Dirichlet Laplacian with a small volume obstacle

Schedule: July 6 14:30-15:00 Room 618

Gianmaria Verzini

Politecnico di Milano, Italy

Co-Author(s): Benedetta Noris, Giovanni Siclari

Abstract:

We consider the well-known shape optimization problem with spectral cost: minimizing the first eigenvalue of the Dirichlet Laplacian among all subdomains Ω having prescribed volume and contained in a fixed box D ; equivalently, we look for the best way to remove a compact set (obstacle) $K \subset \overline{D}$ of Lebesgue measure $|K| = \varepsilon$, $\varepsilon > 0$.

Classification of the Struwe decomposition of the Brezis-Nirenberg problem and its application: The one-bubble case

Schedule: July 6 16:30-17:00 Room 618

Yuanze Wu

School of Mathematics, Yunnan Normal University, Peoples Rep of China

Co-Author(s): Rui He, Xiangqing Liu, Juncheng Wei

Abstract:

I will report our recent results on the classification of the Struwe decomposition of the Brezis-Nirenberg equation in high dimensions for the one-bubble case. I will also report the application of this refined analysis in constructing nontrivial solutions of the Brezis-Nirenberg equation.

Normalized solutions for the Sobolev critical Schrödinger equation with trapping potential

Schedule: July 6 15:00-15:30 Room 618

Junwei Yu

Politecnico di Milano, Italy

Abstract:

In this talk, I would like to present some recent results on the existence and multiplicity of positive solutions in $H^1(\mathbb{R}^N)$, $N \geq 3$, with prescribed L^2 -norm, for the Sobolev critical Schrödinger equation with trapping potential. Under suitable assumptions on the potential, the associated energy functional exhibits a mountain pass geometry on the L^2 -sphere, which yields the existence of both a local minimizer and a mountain pass solution. In particular, for small values of the prescribed mass, we prove the existence of two distinct solutions: a ground state and a mountain pass solution.

**Special Session 8 : Differential, Difference, and Integral Equations:
Techniques and Applications**

Organizer(s): Jeffrey Lyons , Wenying Feng

Introduction: Boundary Value Problems (BVPs) play a critical role in modeling complex phenomena across science, engineering, and real-world systems. With applications spanning from finance and physics to control theory and machine learning, the study of nonlinear BVPs has seen renewed interest in recent years. This Special Session aims to bring together researchers working on BVPs for Ordinary Differential Equations (ODEs), Partial Differential Equations (PDEs), Fractional Differential Equations (FDEs), and their integral and discrete counterparts. Of particular interest are recent advancements in fractional-order differential equations, which have gained prominence due to their emerging applications in diverse fields. We invite contributions that explore novel theories, innovative techniques, and cutting-edge applications of BVPs.

On the existence of solutions to the Cauchy-Dirichlet problem for a class of third-order hyperbolic operators

Schedule: July 9 8:30-9:00 Room 440

Annamaria Barbagallo

University of Naples Federico II, Italy

Co-Author(s): Vincenzo Esposito

Abstract:

The talk is devoted to the analysis of the Cauchy-Dirichlet problem for a class of third-order hyperbolic differential operators in a domain of $\mathbb{R}^3$. The study begins to establish a priori estimates, both local and global, which play a crucial role in controlling the behavior of solutions. These estimates are established through careful analytical procedures that take into account the structure of the operators under consideration. By combining the obtained estimates with appropriate pseudo-differential techniques, an existence theorem is proved.

A family of Gibbs constants for symmetric Krawtchouk expansions

Schedule: July 10 10:30-11:00 Room 440

John Davis

Baylor University, USA

Abstract:

We investigate the Gibbs overshoot for partial sums of symmetric Krawtchouk expansions of a centered sign function. By combining parity reduction, an exact coefficient identity on a neighboring lattice, and one-point WKB asymptotics, we obtain a continuum-limit description of the overshoot profile for degree cutoffs of the form $m \sim \delta N$, where δ is the truncation fraction. This leads to a one-parameter family of discrete Gibbs constants interpolating between the classical Fourier Gibbs constant as an upper bound and a recently numerically observed Krawtchouk Gibbs constant as a lower bound. We discuss how this framework may extend to other discrete orthogonal polynomial families.

Quasilinear eigenvalue estimate for coupled differential equations

Schedule: July 9 9:00-9:30 Room 440

Sougata Dhar

Fairfield University, USA

Co-Author(s): Jessica Kelly, Lisa Naples

Abstract:

In this talk, we present an one dimensional Sobolev-type inequality and use it to obtain the estimates for eigenvalues for even ordered differential equations satisfying periodic and anti periodic boundary conditions. In the higher order periodic case, we introduce suitable moment constraints to eliminate the polynomial kernel, leading to a Sobolev-Poincare inequalities with explicit scaling. In contrast, anti-periodic conditions naturally yield coercive estimates without additional constraints. These Sobolev-type inequalities provide a unified framework for analyzing boundary value problems and serve as the main tool for deriving further spectral and stability results.

On BVP for linear fractional differential equations

Schedule: July 9 9:30-10:00 Room 440

Pavel Dubovski

Stevens Institute of Technology, USA

Co-Author(s): J.A.Slepoi

Abstract:

We demonstrate that boundary value problems on segment $[a, b]$ are not necessarily overdetermined for the first order fractional differential equations and, thus, may be well posed.

Multiple positive solutions for a fractional differential system with nonlocal boundary conditions

Schedule: July 10 12:00-12:30 Room 440

Wenying Feng

Trent University, Canada

Co-Author(s): Y. Cui, S. Kang, H. Chen, L. Li

Abstract:

We prove existence of three positive solutions for a class of Caputo fractional differential equation with nonlocal boundary conditions involving both the first and second-order derivatives. Our result extends the Riemann-Liouville fractional system to the Caputo equation. By converting the problem into a Caputo integral operator, we employ the Leggett-Williams fixed point theorem to establish conditions that ensure existence of three positive solutions. We illustrate the result with examples and numerical simulations that demonstrate one or more nontrivial solutions and highlight parameter regimes yielding multiplicity.

Prolongation of solutions and Lyapunov stability for Stieltjes dynamical systems

Schedule: July 9 14:00-14:30 Room 440

Marlene Frigon

University of Montreal, Canada

Co-Author(s): Marlene Frigon

Abstract:

In the last years, there has been quite an interest in the theory of Stieltjes differential equations which have the important advantage of providing a unified framework to differential equations, discrete equations, dynamic equations on time scales and differential equations with impulses at fixed times. They are particularly useful for modeling evolution processes in which sudden changes and stationary periods occur. In this talk, we present Lyapunov-type results to study the stability of an equilibrium of a Stieltjes dynamical system. We utilize prolongation results to establish the global existence of the maximal solution. We present also examples and applications to population dynamics models.

Modeling Density-Dependent Emigration Between Two Competing Species of Tribolium: Part I -- Methods

Schedule: July 9 17:00-17:30 Room 440

Jerome Goddard II

Auburn University Montgomery, USA

Co-Author(s): J. T. Cronin & R. Shivaji

Abstract:

Emigration is an important ecological process that can substantially affect persistence, coexistence, and spatial population dynamics. In many systems, emigration is influenced by intraspecific density, while the role of interspecific competitor density remains less clear. Motivated by a 12-generation microcosm experiment involving two competing *Tribolium* species, we develop a reaction-diffusion Lotka-Volterra framework for studying density-dependent emigration between habitat patches. The model incorporates patch size, permeability, and density effects on the proportion emigrating from a patch and is parameterized using independent experimental data. To account for uncertainty and biological variability, we consider distributions of parameter values and use these to obtain probabilistic predictions of long-term steady-state behavior. This talk focuses on the experimental setting, the mathematical formulation of the model, parameterization, and the computational framework used to connect the model to observed microcosm dynamics.

Lyapunov-type Inequalities for Even-Order Quasilinear Differential Equations

Schedule: July 9 14:30-15:00 Room 440

Jessica Kelly

Christopher Newport University, USA

Co-Author(s): Sougata Dhar

Abstract:

In this talk, we establish Lyapunov-type inequalities for even-order quasilinear differential equations subject to Dirichlet boundary conditions, considering both constant and variable coefficient cases. We further extend these results to systems of even-order quasilinear differential equations. The inequalities presented generalize classical scalar results, sharpen existing estimates, and yield explicit lower bounds for generalized eigenvalues.

Inverse interior scattering problems for perturbed quantum Bunimovich billiards

Schedule: July 10 11:30-12:00 Room 440

Qi Li

School of Mathematics and Statistics, Shanxi Datong University, Peoples Rep of China

Abstract:

This work investigates the inverse interior scattering problem for quantum Bunimovich billiards subject to small boundary perturbations. We consider billiards whose boundaries are piecewise C^2 perturbations of the original domain, satisfying the generalized defocusing mechanism. An incident field is generated from the center of each perturbed circular arc, and the resulting scattered field is measured on an auxiliary arc. By synthesizing the transformed field expansion method with Fourier analysis and mathematical induction, we develop a procedure to reconstruct the perturbation's shape. We establish that, when the billiard boundary and the auxiliary arc are sufficiently close, the perturbation is uniquely determined by the imaginary part of the total field, yielding an explicit reconstruction formula.

A Purely Algebraic Unified Approach to Linear Differential and Difference Equations

Schedule: July 10 9:00-9:30 Room 440

Vakhtang Lomadze

Javakhishvili State University, Rep of Georgia

Abstract:

Let $(\mathcal{U}, \hbar)$ be a pair consisting of a module $\mathcal{U}$ over the ring of proper rational functions and a nonzero element $\hbar \in \mathcal{U}$. Elements of $\mathcal{U}$ are interpreted as classical functions, with $\hbar$ representing the constant function 1; multiplication by the local parameter is viewed as the integration operator. We assume that the zero function is the only constant function that arises as an integral. Within this framework, we introduce Schwartz distributions of finite order and study linear dynamic equations, encompassing linear differential and difference equations, as well as more general linear dynamic equations on time scales. Acknowledgment: This work was supported by Shota Rustaveli National Science Foundation of Georgia (SRNSFG) [FR-24-8249].

Shooting Method Using Difference Equations

Schedule: July 10 8:00-8:30 Room 440

Jeffrey Lyons

The Citadel, USA

Co-Author(s): Douglas Anderson, Richard Avery, Johnny Henderson

Abstract:

We introduce a new fixed point shooting method that replaces the classical continuous shooting technique with a sequence of discrete initial value problems. Each discrete problem is easy to solve and collectively provides a high fidelity approximation to the trajectory of the corresponding continuous boundary value problem. Using these trajectories, we then construct a difference equation approximation to the original boundary value problem and establish rigorous error bounds for the method. This discrete framework offers both theoretical and computational advantages, as difference equations are often simpler to analyze and implement while retaining strong approximation properties. To demonstrate the effectiveness of the method, we apply it to a right focal boundary value problem and highlight its accuracy and efficiency.

Existence and asymptotics of global positive solutions to a nonlinear differential system of fractional order via extension of Karamata theory

Schedule: July 9 15:00-15:30 Room 440

Serena Matucci

Department of Mathematics and Computer Sciences, Italy

Co-Author(s): Pavel $\backslash v\{R\}eh\backslash ak$

Abstract:

In this talk some results are presented about the existence and the precise asymptotic behavior for positive global solutions of a system of two differential equation of fractional order. The aims is both to generalize some of the results known for the ordinary case to the fractional case, and to analyze the role of fractional order, putting in evidence purely fractional phenomena. Under the assumption that the coefficients are $\textit{regularly varying}$ functions at infinity, an extension of the Karamata integration theorem to fractional integration enables the use of a fixed-point approach to prove the existence of positive unbounded solutions satisfying given asymptotic conditions, since it provides sharp two-sided estimates for the solutions. Furthermore, conditions are found under which all solutions with nonnegative initial conditions are regularly varying at infinity with a prescribed index. We then apply these results to the special case of a scalar equation of order $1 + \alpha$, highlighting both the analogies and discrepancies with the integer-order case.

Fixed point theorems in orders metric and Banach spaces based on degree of nondensifiability and applications

Schedule: July 10 8:30-9:00 Room 440

Abdelghani Ouahab

University of Djillali Liabes Sidi Bel Abbes, Algeria

Abstract:

Using the concept of the degree of nondensifiability in ordered metric and Banach spaces, we establish fixed point theorems for monotone operator contractions with respect to the degree of nondensifiability and condensing mappings. Our results extend and unify several classical and recent results available in the literature. Furthermore, we apply the main results to study the existence of minimal maximal mild solutions for certain classes of semilinear differential equations.

NONSTANDARD DISCRETIZATION SCHEME IN VOLTERRA INTEGRO-DIFFERENTIAL EQUATIONS THAT PRESERVES UNIFORM ASYMPTOTIC STABILITY

Schedule: July 9 8:00-8:30 Room 440

Youssef N Raffoul

University of Dayton, USA

Co-Author(s): SVETLIN G. GEORGIEV, Halis Can Koyuncuo\u{g}lu, Marko Kostić

Abstract:

We apply a nonstandard discretization scheme to continuous Volterra integro-differential equations and we show that under this discretization, the necessary and sufficient conditions for uniform asymptotic stability of continuous Volterra integro-differential equations are preserved. Our analysis is based on the notion of resolvent. An example is provided as an application to our theory.

Asymptotic stability of differential equations with impulses and distributed delay

Schedule: July 9 15:30-16:00 Room 440

Paola Rubbioni

University of Perugia, Italy

Co-Author(s): T. Cardinali, S. Matucci

Abstract:

Differential equations with memory and impulsive effects arise in a variety of physical and biological models. When formulated in appropriate function spaces, classes of distributed-delay models can be represented as integro-differential or functional differential equations. We establish general conditions guaranteeing existence, uniqueness, uniform asymptotic stability, and exponential stability of solutions on the half-line, even under impulsive perturbations. Applications illustrate these results in population dynamics and flexible robotic arms with integral and evanescent memory. \bibitem{cmr25} Cardinali T.; Matucci S.; Rubbioni P.; Uniform asymptotic stability of a PDE's system arising from a flexible robotics model, Math. Methods Appl. Sci. 48 (2025), no. 11, 11242-11251 \bibitem{cmr26} Cardinali T., Matucci S., Rubbioni P., Stability of solutions in impulsive integro-differential equations with applications to fading memory systems, Commun. Nonlinear Sci. Numer. Simulat. 154 (2026) 109588 \bibitem{r21} Rubbioni, P.; Asymptotic stability of solutions for some classes of impulsive differential equations with distributed delay, Nonlinear Anal. Real World Appl. 61 (2021), 103324

Passive inverse problems: stability and neural network solutions

Schedule: July 10 11:00-11:30 Room 440

Darko volkov

Worcester Polytechnic Institute, USA

Co-Author(s): S. C. Hawkins, M. Ganesh, and F. Triki

Abstract:

Typical PDE based nonlinear inverse problems involve a known forcing term and a feature (such as coefficient or inner geometry feature) to be recovered using overdetermined boundary data. However, this does not apply to passive inverse problems. In these problems, the forcing term in the PDE is unknown while the geometry of a feature has to be recovered. There are thus both linear and nonlinear unknowns. We focus on recovery of cracks in unbounded domains with propagating waves. We present recent results regarding the stability of the Hausdorff distance between cracks, (Triki and Volkov, 2025). Next, we examine the case where cracks are defined through a vector parameter m while the forcing term for the PDE is still in an infinite dimensional space (Ganesh, Hawkins, and Volkov, 2026). We proved Lipschitz continuity of a related inverse operator if the forward operator is restricted to m -dependent finite dimensional spaces. These finite dimensional spaces are spanned by m -dependent singular functions which can be computed. This led us to build neural networks that can solve the crack inverse problem. The solution is computed in an efficient non-iterative way and is robust to noise.

Physics-informed stochastic models for theme park ride waiting times

Schedule: July 9 16:30-17:00 Room 440

Min Wang

Kennesaw State University, USA

Co-Author(s): Min Wang

Abstract:

A stochastic model for theme-park ride waiting times is developed by modeling the waiting time as a continuous-time, discrete-state Markov process with state-dependent, time-varying transition rates. These transition rates are interpreted as a time-dependent feedback control acting on the waiting-time process, allowing us to formulate the model calibration task as a data-driven optimal control problem. To solve this problem efficiently, we construct a physics-informed neural network (PINN) that embeds the controlled Kolmogorov forward equation into its architecture. Under mild assumptions, we prove the existence of an optimal time-dependent feedback control, providing theoretical support for the learning procedure. Numerical simulations are conducted to demonstrate the effectiveness of the PINN-based solution. The framework provides an interpretable, physically consistent, and data-driven approach for modeling and forecasting ride waiting times.

Uniqueness of meromorphic functions sharing values with their difference polynomials

Schedule: July 10 9:30-10:00 Room 440

Huicai Xu

Shanxi Datong University, Peoples Rep of China

Abstract:

In this work, we deal with the open question 3IM+1CM in the uniqueness theory of meromorphic functions and we prove that when a non-constant finite order meromorphic function f and its difference polynomials $L(z, f)$ satisfy the condition 3IM+1CM, then $f \equiv L(z, f)$ or $f \equiv -L(z, f)$ holds.

Structure of polar director for bent-core smectic A liquid crystals in thin planar cells

Schedule: July 9 17:30-18:00 Room 440

Xiaodong Yan

University of Connecticut, USA

Co-Author(s): Alec Wendland

Abstract:

We study the polar director structure in thin planar cells filled with bent-core liquid crystals in the ferroelectric smectic-A phase (SmAPF). We analyze a continuum phenomenological model proposed by Gornik et al., present rigorous proof of existence and uniqueness of the equilibrium solutions, and discuss qualitative properties of nontrivial solutions. The effects of bias electric field, surface anchoring and cell thickness on the structure of polar director are also discussed. Our results agree with previous experimental and numerical simulations in the physics literature.

Special Session 9 : Stochastics and randomness in physical models

Organizer(s): Luca Scarpa , Margherita Zanella

Introduction: The aim of this session is to present recent developments in the theory of stochastic partial differential equations arising in physical models, such as dynamics of fluids, mixtures, and dispersive phenomena. In fact, the presence of randomness in the description of physical phenomena has turned out to be crucial in order to model disturbances, such as oscillatory behaviours, microscopic uncertainty, and temperature oscillations. This has contributed to the development of probabilistic techniques to treat qualitative and quantitative properties of the underlying stochastic models.

Moments estimates and sharp interface limit for the stochastic Cahn-Hilliard equation

Schedule: July 10 17:30-18:00 Room 620

Dimitra Antonopoulou

National and Kapodistrian University of Athens, Greece

Abstract:

The phase separation process in a binary alloy is parameterized by a small positive parameter ε representing the order of the width of the evolving layers. Stochastic versions for the equations modelling the evolution of the concentration of the phases arise due to thermal fluctuations, external mass supply or impurities in the alloy. We consider the ε -dependent stochastic Cahn-Hilliard equation with multiplicative and sufficiently regular in space noise with strength of order $O(\varepsilon^\gamma)$, $\gamma > 0$ in dimensions $d = 1, 2, 3$. We prove p -moments estimates in H^1 , H^2 and L^∞ norms. When the initial data are layered by using the energy (H^1) estimate we prove that, as ε tends to 0, the solution $u \rightarrow \pm 1$ in the L^2 norm with probability tending to 1. This implies the complete separation of the two phases on the sharp interface limit even in the presence of noise.

Absence of anomalous dissipation in passive scalars advected by random autonomous drifts

Schedule: July 10 14:30-15:00 Room 620

Marco Bagnara

Imperial College London, England

Co-Author(s): Daniel W. Boutros, Camillo De Lellis, Svitlana Mayboroda

Abstract:

We prove the absence of anomalous dissipation for passive scalars driven by some random autonomous divergence-free vector fields in $\mathbb{T}^d$. In dimension $d = 2$ we just need continuity almost surely and a mild nondegeneracy condition on the randomness. In dimension $d \geq 3$ we assume a special geometric structure and almost sure Hölder regularity with exponent bigger than $\frac{1}{8}$. No regularity is assumed on the passive scalar except for boundedness in the initial data. The proof relies on dimension-theoretic arguments, as opposed to commutator estimates. A consequence of these results is that the same assumptions prevent (almost surely) many other expected properties of turbulent flows, such as anomalous regularization, the Yaglom-Obukhov-Corrsin law, and Richardson diffusion.

Continuous data assimilation for 2d stochastic Navier-Stokes

Schedule: July 10 13:30-14:00 Room 620

Hakima Bessaih

Florida International University, USA

Co-Author(s): B. Ferrario, O. Landoulsi, M. Zanella

Abstract:

We extend the Azouani-Olson-Titi (AOT) data assimilation framework to the two-dimensional stochastic Navier-Stokes equations with additive and multiplicative noise. We establish conditions on the nudging parameter and observation scale ensuring convergence of the assimilated solution to the true flow. Convergence rates are obtained for both the multiplicative and additive noises. These results provide a stochastic extension of AOT and highlight the role of noise in synchronization of fluid flows.

Pathwise uniqueness for stochastic PDEs with singular Hölder continuous drift

Schedule: July 10 15:00-15:30 Room 620

Davide Augusto Bignamini

Università degli studi dell'Insubria, Italy

Co-Author(s): D. Addona, C. Orrieri, L. Scarpa

Abstract:

In this talk, we will discuss pathwise uniqueness for mild solutions to stochastic PDEs with drift given in differential form. The key example that we want to study is the following SPDE evolving in $H = L^2([0, 1]^d)$ with $d \in \{1, 2, 3\}$

$$dX(t) + A^\gamma X(t) dt = B(X(t)) dt + A^{-\rho} dW(t), \quad X(0) = x,$$

where $\{W(t)\}_{t \geq 0}$ is an H -cylindrical Wiener process, $-A$ is a suitable realization of the Laplacian in H , $B : D(A^\mu) \rightarrow D(A^{-\nu})$ is locally θ -Holder continuous with $\theta \in (0, 1)$, $\gamma > 0$ and $\mu, \nu, \rho \geq 0$ are given constants. Under suitable assumptions on $\gamma > 0$ and $\mu, \nu, \rho \geq 0$, we will show that the pathwise uniqueness holds in $D(A^\mu)$. The singularity of the drift perturbation B allows to achieve novel pathwise uniqueness results for several classes of examples, ranging from fluid-dynamics to phase-separation models.

The stochastic Cahn--Hilliard equation with singular potential, degenerate mobility and transport noise

Schedule: July 10 14:00-14:30 Room 620

Andrea Di Primio

Scuola Normale Superiore, Italy

Abstract:

In this talk, I will introduce the stochastic Cahn--Hilliard equation with singular potential, variable mobility and driven by transport noise. In particular, the mobility is allowed to be degenerate. After illustrating some generalities concerning the model, results on the well-posedness of the system are addressed, in terms of existence and uniqueness of martingale and/or probabilistically-strong solutions. This is joint work with Andrea Papini (Chalmers University of Technology), Luca Scarpa (Politecnico di Milano) and Margherita Zanella (Politecnico di Milano). The mentioned activities are carried out within the project: NoisyFluid "Noise in Fluids", Grant Agreement 101053472, CUP E53C22001720006.

The nonlinear Schrödinger equation with multiplicative noise and arbitrary power of the nonlinearity

Schedule: July 10 10:30-11:00 Room 620

Benedetta Ferrario

University of Pavia, Italy

Co-Author(s): Zdzislaw Brzezniak, Mario Maurelli, Margherita Zanella

Abstract:

We consider the stochastic nonlinear Schrödinger equation with the polynomial nonlinearity

$$du(t, x) + \left[i\Delta u(t, x) + i\alpha |u(t, x)|^{2\sigma} u(t, x) \right] dt = \phi(u(t, x)) dW(t)$$

Classical results of global existence are obtained for power σ not too large, depending on the spatial dimension d and the parameter α ($\alpha > 0$ is the focusing case and $\alpha < 0$ is the defocusing case). The effect of the noise is to prevent blow-up in finite time, differently from the deterministic setting. Moreover, we prove the existence of an invariant measure and its uniqueness under more restrictive assumptions on the noise term. As an example, one can consider a one dimensional real Wiener process W and diffusion $\phi(u) = [a(1 + \|u\|_{L^\infty(\mathbb{T}^d)}^\sigma) + ib(1 + \|u\|_{L^\infty(\mathbb{T}^d)}^\sigma)]u$ for real values a, b with a large enough. The choice $s > \frac{d}{2}$ provides the helpful estimate $\|u\|_{L^\infty(\mathbb{T}^d)} \leq C\|u\|_{H^s(\mathbb{T}^d)}$, because of the continuous embedding $H^s(\mathbb{T}^d) \subset L^\infty(\mathbb{T}^d)$. Therefore the local existence result is a trivial fact. Our proof of global existence relies on a tightness method based on the choice of a suitable Lyapunov function. In particular, the global existence holds in both focusing and defocusing cases.

Fluctuations for mean field limits of singular interacting particle systems driven by fBm

Schedule: July 10 8:30-9:00 Room 620

Lucio Galeati

University of L'Aquila, Italy

Co-Author(s): Avi Mayorcas, Johanna Weinberger

Abstract:

We consider a system of N particles, subject to a mean-field type pairwise interaction kernel K , each driven by an independent fractional Brownian motion (idiosyncratic noises). Previous works established that, for a large class of non-Lipschitz, possibly singular kernels, the associated McKean-Vlasov equation is well-posed, and the empirical measure converges to its law as $N \rightarrow \infty$, with rate of order $N^{-1/2}$ in suitable negative Sobolev norms. In this talk I will present results concerning the Gaussian fluctuations underlying this mean field convergence, validating the optimality of this rate; they are valid for both first order interactions and for kinetic systems. The proofs are based on the use of Girsanov transform and the method of U-statistics first introduced by Sznitman. Based on joint work with Avi Mayorcas (Bath) and Johanna Weinberger (Technion).

On new results in the well-posedness of stochastic reaction diffusion models

Schedule: July 10 17:00-17:30 Room 620

Fabian Germ

Delft University of Technology, Netherlands

Co-Author(s): Mark Veraar, Antonio Agresti

Abstract:

In this talk I will present some new results regarding the existence, uniqueness and regularity of solutions to stochastic reaction-diffusion models. The solution theory will be established in general Banach spaces. Using refined estimates, we obtain well-posedness for a wider class of systems, allowing for instance non-linearities with higher growth. Additional properties like blow-up criteria and instantaneous regularization of solutions will also be presented. If time permits, extensions to models with non-trace class noise will also be shown. While the results will be formulated in general Banach spaces, they will be motivated by concrete examples from Biology and related disciplines. This is joint work with Antonio Agresti and Mark Veraar.

Small Noise Asymptotics for Nonlinear Reaction-Diffusion Equations

Schedule: July 10 9:30-10:00 Room 620

Giuseppina guatteri

Politecnico di Milano, Italy

Co-Author(s): Sandra Cerrai, Gianmario Tessitore

Abstract:

This talk is based on joint work with Sandra Cerrai and Gianmario Tessitore. We present well-posedness and small-noise asymptotic results for a class of stochastic reaction-diffusion equations on bounded domains, driven by nonlinear and temporally nonlocal multiplicative noise. The diffusion coefficient depends on the solution through a conditional expectation at the final time, while the reaction term is only assumed to be continuous and quasi-dissipative, with no growth bounds or local Lipschitz assumptions. To handle these difficulties, we avoid relying on the theory of infinite-dimensional quasilinear PDEs and instead work directly at the SPDE level, combining a mild formulation with a Salins-type solution map and contraction arguments. This yields existence and uniqueness for sufficiently small noise, as well as a large deviation principle for the laws of the solution trajectories.

Motion planing with fractals - a rough path approach

Schedule: July 10 11:30-12:00 Room 620

Erika Hausenblas

Technical University of Leoben, Austria

Abstract:

A control system is called non-holonomic when it cannot move instantaneously in all directions of its state space: at each configuration, only a lower-dimensional set of admissible velocities is available. A canonical example is the unicycle, which can roll forward and backwards and rotate, but cannot slide sideways, so lateral motion is not directly actuated. A similar constraint arises in the classical parallel-parking manoeuvre. From a dynamical viewpoint, the missing directions can be generated through Lie brackets of the control vector fields. Traditionally, motion along Lie bracket directions is achieved using carefully designed switching or oscillatory controls, such as bang-bang strategies or sinusoidal averaging. In this work, we took another approach. We introduce explicit Koch-type fractal controls that generate targeted motions along Lie-bracket directions using short-time inputs. To establish well-posedness for control systems driven by such fractal signals, we apply tools from rough path theory. As model problems, we illustrate our approach through bracket-induced lateral motion for the unicycle and a higher-order steering mechanisms in coupled trailer-type systems.

Anomalous Regularization and Dissipation for 2D Euler Equations with Rough Kraichnan Noise

Schedule: July 10 16:30-17:00 Room 620

Eliseo Luongo

Bielefeld University, Germany

Co-Author(s): Lucio Galeati, Umberto Pappalettera

Abstract:

In the 1960s, Robert Kraichnan [Kraichnan 1968] proposed a synthetic model for passive scalar turbulence, consisting of a scalar advected by a random Gaussian velocity field that is white in time and Hölder continuous in space. Despite its simplicity, this linear SPDE exhibits key features of realistic turbulent flows, such as anomalous dissipation. Renewed interest in this model followed [Coghi, Maurelli 2023], where it was proved that the same transport-type noise restores well-posedness in regimes where the deterministic 2D Euler equations admit non-unique weak solutions. In this talk, we further develop this line of research by investigating additional properties of the solutions constructed in [Coghi, Maurelli 2023]. In particular, we present new results on anomalous fractional Sobolev regularity and anomalous dissipation of the mean enstrophy for solutions to the 2D Euler equations with rough Kraichnan noise. Time permitting, we will also discuss implications for the well-posedness theory of more singular nonlinear advection models, such as the Surface Quasi-Geostrophic and Incompressible Porous Media equations. This talk is based on ongoing joint work with L. Galeati and U. Pappalettera.

Bismut-Elworthy type formulae for BSDEs with degenerate noise and related Kolmogorov equations

Schedule: July 10 15:30-16:00 Room 620

Federica Masiero

Milano-Bicocca University, Italy

Co-Author(s): Davide Addona

Abstract:

In this talk we present how to derive Bismut-Elworthy formula under assumptions weaker than non degeneracy of the noise. We can apply our results to stochastic (damped) wave equations, whose regularizing properties of the transition semigroup are discussed. We present a nonlinear version of the Bismut formula for BSDEs, and we discuss applications to the solution of semilinear Kolmogorov equations.

On the stochastic H^1 -critical Non Linear Schrödinger equation

Schedule: July 10 12:00-12:30 Room 620

Annie A MILLET

University Paris 1 Pantheon Sorbonne, France

Co-Author(s): Svetlana Roudenko

Abstract:

We prove local well posedness for the focusing/defocusing stochastic NLS equation in dimension 3 to 5 for an H^1 -critical nonlinearity and an additive/multiplicative stochastic perturbation. In the case of a focusing nonlinearity, we give criteria on the initial condition to obtain either some quantitative information about the maximal existence time, or blow-up with positive probability.

Anomalous dissipation and regularization in isotropic Gaussian turbulence

Schedule: July 10 11:00-11:30 Room 620

Umberto Pappalettera

University of Basel, Switzerland

Co-Author(s): Theodore D. Drivas, Lucio Galeati

Abstract:

In this work we rigorously establish a number of properties of turbulent solutions to the stochastic transport and the stochastic continuity equations constructed by Le Jan and Raimond in [Ann. Probab. 30(2): 826-873, 2002].

Finite Speed of Propagation and Waiting Time Phenomena for Stochastic Porous-Media Equations with Nonlinear Conservative Noise

Schedule: July 10 9:00-9:30 Room 620

Joshua Utley

Friedrich Alexander University Erlangen Nuremberg, Germany

Co-Author(s): Guenther Gruen, Max Sauerbrey

Abstract:

We are concerned with stochastic porous media equations with nonlinear conservative noise and show that for super-linear and sub-critical noise parameters, kinetic solutions have finite speed of propagation. In particular, we propose a novel iteration technique which allows us to obtain a Stampacchia-type inequality involving one single integral quantity, despite the possibly different scaling behaviors of the porous media and the noise term. This allows us to apply directly the stochastic filtering argument developed in [SIAM J. Math. Anal. 47 (2015), 825--854]. Using related ideas, we identify flatness conditions on initial data which guarantee locally the occurrence of a waiting time phenomenon, i.e., the onset of forward propagation of the solution's support is locally delayed. The condition for the latter matches the one for $B = 0$ up to a logarithmic correction if $n = (m + 1)/2$, but it requires more and more flatness of the initial data as $n \rightarrow 1$. This is in line with the expected behavior of u : For $n = 1$ an instantaneous forward motion is possible due to the effects of stochastic transport, no matter how flat the initial profile is.

New methods in Large deviations for SPDE

Schedule: July 10 8:00-8:30 Room 620

Mark Veraar

TU Delft, Netherlands

Co-Author(s): Antonio Agresti and Esmee Theewis

Abstract:

In this talk, I will give an overview of new results on large deviations for stochastic evolution equations. Even in the variational setting, this leads to new results, as we assume neither monotonicity nor a compact embedding in the Gelfand triple. In particular, our framework applies to 2D Navier-Stokes equations on (un)bounded domains, 3D Primitive Equations, and reaction-diffusion equations. While the arguments are still based on the weak convergence approach, the main new ingredients come from the theory of critical spaces and maximal regularity techniques. Based on joint work with Antonio Agresti and Esmee Theewis

Special Session 10 : Recent Developments in Regularity Theory for PDEs

Organizer(s): Zongyuan Li , Hongjie Dong

Introduction: The analysis of elliptic and parabolic partial differential equations remains a fundamental area of research, particularly when addressing challenges posed by irregular domains, rough coefficients, degeneracy, singularities, and nonlinear effects. This special session will focus on recent advances in regularity theory for such equations, as well as their applications in fluid dynamics, kinetic theory, and material science. By bringing together experts in these areas, the session aims to foster discussions on novel techniques, outstanding open problems, and future research directions.

Entire solutions and asymptotic behavior to a class of parabolic k-Hessian equations

Schedule: July 9 15:00-15:30 Room 620

Ning Cao

Southeast University, Peoples Rep of China

Co-Author(s): Cao Ning and Jiang Feida

Abstract:

In this talk, we make a systematic investigation of the existence, uniqueness and nonexistence of entire separable variable radial solutions to the following class of parabolic k-Hessian equations with the parameter:

$$-u_t[S_k(D^2u)]^\alpha = 1$$

We also study the asymptotic behavior and its refined version of the solution at infinity. We particularly note that our results fully generalize the result of An, Bao, et al. in Nonlinear Anal. 239:113441 (2024) for the parabolic Monge-Ampère equation in the form of $-u_t \det D^2u = 1$. The main tools employed in this work comprise Euler's broken line method, local boundedness estimate, Keller-Osserman type criteria, the generalized L'Hospital's rule, and asymptotic stability analysis.

Stationary Stokes systems in non-divergence and double divergence form

Schedule: July 9 8:00-8:30 Room 620

Jongkeun Choi

Pusan National University, Korea

Co-Author(s): Seick Kim

Abstract:

We study stationary Stokes systems in non-divergence form with DMO coefficients and data. We prove that if (u, p) is a strong solution of the system, then $(D^2u, \nabla p)$ is continuous. The corresponding boundary regularity result on a $C^{2,Dini}$ domain is also established. To this end, we introduce the adjoint system associated with the non-divergence form Stokes system, which is formulated in double divergence form.

The hydrodynamic limit of the discrete-velocity BGK Boltzmann equation

Schedule: July 9 17:00-17:30 Room 620

Zhongyang Gu

Shenzhen University, Peoples Rep of China

Co-Author(s): Xin Hu, Tsuyoshi Yoneda

Abstract:

In this talk, we will present the construction of a global weak solution to the 3-dimensional incompressible Navier-Stokes equations through the study of the hydrodynamic limit of the discrete-velocity BGK Boltzmann equation, provided the smallness of the initial data. In particular, the derivation of the diffusion term from the microstructure will be explained. This talk is based on a joint work with Xin Hu (Wuhan University) and Tsuyoshi Yoneda (Hitotsubashi University).

The free boundary for a superlinear system

Schedule: July 9 8:30-9:00 Room 620

Seongmin Jeon

Hanyang University, Korea

Co-Author(s): Daniela De Silva, Henrik Shahgholian

Abstract:

In this talk, we discuss superlinear systems that give rise to free boundaries. Such systems appear for example from the minimization of the energy functional

$$\int_{\Omega} \left(|\nabla \mathbf{u}|^2 + \frac{2}{p} |\mathbf{u}|^p \right), \quad 0 < p < 1,$$

but solutions can be also understood in an ad hoc viscosity way. First, we prove the optimal regularity of minimizers using a variational approach. Then, we apply a linearization technique to establish the $C^{1,\alpha}$ -regularity of the "flat" part of the free boundary via a viscosity method. Finally, for minimizing free boundaries, we extend this result to analyticity.

Dirichlet problem and regular boundary points for elliptic equations in non-divergence and double divergence form

Schedule: July 9 9:00-9:30 Room 620

Dong-ha Kim

Research Institute of Mathematics, Seoul National University., Korea

Co-Author(s): Hongjie Dong, Seick Kim

Abstract:

We consider the Dirichlet problem for second-order elliptic equations in non-divergence form L and double divergence form L^* . We introduce a potential theory framework for these operators, including Perron's method, capacity theory, and Wiener's criterion. We establish the equivalence between regular boundary points for these operators L and L^* with those for the Laplace operator, assuming that the principal coefficients satisfy the Dini mean oscillation condition.

Improving Physics-Informed Neural Networks via Sobolev Trace Regularization

Schedule: July 9 9:30-10:00 Room 620

Doyoon Kim

Korea University, Korea

Co-Author(s): Junbin Song

Abstract:

We study the formulation of Physics-Informed Neural Networks (PINNs) for elliptic boundary value problems from the perspective of Sobolev space theory. Standard PINN approaches enforce boundary conditions using discrete $L_2(\partial\Omega)$ penalties, which are not consistent with the trace space of $H^1(\Omega)$. To address this mismatch, we introduce Trace Regularity Physics-Informed Neural Networks (TRPINNs), in which boundary data are enforced in the Sobolev-Slobodeckij space $H^{1/2}(\partial\Omega)$. We develop a computationally efficient approximation of the corresponding semi-norm that retains its essential structure while avoiding numerical instabilities. We show that this formulation yields convergence in the $H^1(\Omega)$ norm and provide numerical evidence demonstrating improved performance, particularly for problems with highly oscillatory boundary data.

On the Aleksandrov-Bakelman-Pucci estimate for 1-Laplace-type equations

Schedule: July 9 14:30-15:00 Room 620

Shuhei Kitano

Waseda University, Japan

Abstract:

In this talk, I will present a new L^∞ bound for solutions to the Poisson problem associated with the weighted 1-Laplacian. This estimate is analogous to the classical result for uniformly elliptic equations established independently by Aleksandrov, Bakelman, and Pucci in the 1960s, and it is based on an analysis of the contact set of the solutions and their quasiconcave envelopes.

A regularity theory for fractional parabolic equations

Schedule: July 9 13:30-14:00 Room 620

Junhee Ryu
KIAS, Korea

Abstract:

In this talk, we study a class of fractional parabolic equations. We present continuity of fractional parabolic operators and the unique strong solvability of the corresponding parabolic equations in L_p spaces.

The Isometric Study of Wasserstein Spaces- Bounded Intervals

Schedule: July 9 15:30-16:00 Room 620

Chuanlong Sun
Southeast University, Peoples Rep of China

Co-Author(s): Tiren Huang

Abstract:

The isometric rigidity of Wasserstein spaces and PDEs are inherently interconnected through the optimal transport theory, with the Monge-Ampère equation serving as the core link. In this talk, based on the work of Geher, Titkos, and Virosztek, we extend their rigidity results on $[0,1] \rightarrow [0,1]$ to different bounded intervals. Particularly, we give the characterization of isometries of $p=1$ and $p>1$, and we find the exotic isometries for $p=1$.

Some studies on the regularity of solutions to degenerate or singular equations with gradient terms

Schedule: July 9 14:00-14:30 Room 620

Jiangwen Wang
School of Mathematics, Southeast University, Peoples Rep of China

Co-Author(s): Jiangwen Wang, Feida Jiang

Abstract:

In this talk, we consider $C^{1,\alpha}$ regularity of solutions to degenerate normalized p -Laplacian equations and degenerate or singular fully nonlinear integro-differential equations. If time allows, we will also introduce related applications, such as dead-core problems. This talk is based on joint works with Prof. Feida Jiang.

Mixing flow and advection-diffusion equations

Schedule: July 9 16:30-17:00 Room 620

Xiaoqian Xu
Duke Kunshan University, Peoples Rep of China

Abstract:

In the study of incompressible fluid, one fundamental phenomenon that arises in a wide variety of applications is dissipation enhancement by so-called mixing flow. In this talk, I will give a brief introduction to the idea of mixing flow and examples of such flows. In addition, I will also discuss the un-mixing property of the diffusion process.

Special Session 11 : Stochastic Partial Differential Equations

Organizer(s): Benjamin Gess , Michael Röckner

Introduction: Stochastic Partial Differential Equations (SPDE) and their applications is a relatively young field of mathematics. In the past two decades it has, however, become one of the main research directions of Probability Theory, with rising activity across its entire spectrum. In particular, modern SPDE techniques and their combination with ideas from rough path theory led to Martin Hairer's theory of regularity structures for which he was awarded the Fields medal in 2014. Since then this theory has been significantly extended, for example, by applications to the geometrical evolution of random loops on manifolds. The field of SPDE combines the classical area of Partial Differential Equations (PDE) with modern branches of Probability Theory, in particular, Stochastic Analysis, and thus constitutes one of the most prominent contact points between Analysis and Stochastics. Besides various other connections to pure mathematics (e.g. Differential Geometry, Dynamical Systems) one main focus of SPDE are its applications to the Sciences, in particular Physics, but also Biology and Chemistry. Another main area of applications is Economics, in particular Mathematical Finance.

On spectral gaps for Stochastic Wave equations.

Schedule: July 8 8:30-9:00 Room 438

Nikolay Barashkov

Max Planck Institute for Mathematics in the Sciences, Germany

Co-Author(s): Giacomo di Gesu, Petri Laarne

Abstract:

We will discuss Spectral Gap of Stochastic Wave equations with additive noise, and its relation to the heat equation case. Our methods combine techniques from Hypocoercivity in an infinite dimensional setting, with techniques from singular SPDEs.

Concentration results for time-dependent SPDEs with Gaussian and fractional noise

Schedule: July 8 15:00-15:30 Room 438

Nils Berglund

IDP, University of Orleans, France

Co-Author(s): Alexandra Blessing, Rita Nader

Abstract:

We consider slowly time-dependent parabolic SPDEs on the torus of dimension 1 or 2, driven by either Gaussian, or by fractional space-time white noise with Hurst parameter strictly above $1/4$. We obtain concentration estimates for solutions near stable critical curves of these equations. As an application, we prove a quantitative result on stochastic resonance for periodically forced SPDEs. References: 1. NB, Rita Nader, Stochastic resonance in stochastic PDEs, *Stochastics and Partial Differential Equations: Analysis and Computations*, 11:348-387 (2023). 2. NB, Rita Nader, Concentration estimates for slowly time-dependent singular SPDEs on the two-dimensional torus, *Electronic J. Probability* 29:1-35 (2024). 3. NB, Alexandra Blessing (Neamtu), Concentration estimates for SPDEs driven by fractional Brownian motion *Electron. Commun. Probab.* 30:1-13 (2025).

Renormalization destroys a finite time bifurcation in the Φ_2^4 equation

Schedule: July 8 14:00-14:30 Room 438

Alexandra Blessing

University of Konstanz, Germany

Co-Author(s): Nicolas Perkowski, Chara Zhu

Abstract:

We study the singular Φ_2^4 equation at a pitchfork bifurcation of the underlying deterministic dynamics. To this aim, we linearize the SPDE along its stationary solution and show that the support of its finite-time Lyapunov exponents (FTLEs) is the real line, regardless of the bifurcation parameter and in sharp contrast to the non-singular Φ_1^4 equation. The proof relies on a support theorem for the stationary solution and its renormalized square.

Uniqueness for stochastic differential equations in Hilbert spaces with irregular drift

Schedule: July 9 18:00-18:30 Room 438

Oleg Butkovsky

Weierstrass Institute (WIAS), Germany

Abstract:

Joint work with Lukas Anzeletti, Máté Gerencsér, Alexander Shaposhnikov. We obtain strong uniqueness for SDEs in Hilbert spaces with irregular drift:

$$dX_t = (AX_t + b(X_t))dt + (-A)^{-\gamma/2}dW_t, X_0 = x \in H,$$

where H is a separable Hilbert space, A is a self-adjoint negative definite operator, W is a cylindrical Wiener process, b is an α -Hölder continuous function $H \rightarrow H$, $\gamma \geq 0$. We show that this equation has a unique strong solution provided that $\alpha > \alpha^*(\gamma)$, with an explicit function α^* that takes values in $(0, 1)$ for all $\gamma \in [0, 3)$. This substantially extends the seminal work of Da Prato and Flandoli (2010), as no structural assumption on b is imposed. To obtain this result, we do not use infinite-dimensional Kolmogorov equations but instead develop a new technique combining Lévy's theory of stochastic sewing in Hilbert spaces, Gaussian analysis, and the method of Lasry and Lions for approximation in Hilbert spaces.

A stochastic homogeneization approach to supercritical SPDEs

Schedule: July 9 18:30-19:00 Room 438

Giuseppe Cannizzaro

University of Warwick, England

Abstract:

In the present talk, we will present a novel approach to study the large-scale fluctuations of a class of stationary quasi-linear SPDEs at super-critical dimensions. In particular, we show that this class of SPDEs has Gaussian fluctuations and that the limit is given by a linear additive Stochastic Heat equation with renormalised coefficients. Our approach is based on a suitable two-scale expansion for the generator of our dynamics and extends classical stochastic homogenization to the infinite-dimensional setting. Byproducts of our methods are that we obtain quantitative rates for the convergence of the microscopic generator to the limiting one and a more transparent characterisation of the macroscopic diffusivity in terms of microscopic observables. Based on joint ongoing work with H. Giles (TU Vienna) and L. Grafner (Warwick).

Transposition Approach to Optimal Control of McKean-Vlasov SPDEs

Schedule: July 9 17:00-17:30 Room 438

Liangying Chen

FU Berlin & TU Berlin, Germany

Co-Author(s): Wilhelm Stannat

Abstract:

We introduce the notion transposition solution for a class of McKean-Vlasov backward stochastic partial differential equations, providing a flexible framework to establish well-posedness under low regularity conditions via duality methods. This approach is particularly suited to infinite-dimensional stochastic systems where the given filtration is not natural. As an application, we study optimal control problems governed by McKean-Vlasov stochastic partial differential equations, in which the coefficient depend on both the state and its probability distribution. Within this framework, we derive first-order necessary optimal conditions in the form of a stochastic maximum principle, where the corresponding adjoint equations are characterized as BSPDEs in the transposition sense.

Large field problem in coercive SPDE via scaling

Schedule: July 9 13:30-14:00 Room 438

Ilya Chevyrev

SISSA (International School for Advanced Studies), Italy

Co-Author(s): Massimiliano Gubinelli

Abstract:

In this talk, I will show an approach to deriving a priori bounds for coercive SPDEs based on scaling. The basic idea is to first show bounds for the equation with a small noise and then rescale the bounds to a global scale. While many equations that the approach can handle have been treated recently with other methods, its advantages are that it is simple and allows one to state a single result that is applicable to a variety of equations, such as rough differential equations and parabolic/elliptic SPDEs.

It\^o perspective on variance renormalisation

Schedule: July 9 14:00-14:30 Room 438

Konstantinos Dareiotis

University of Leeds, England

Co-Author(s): M\^at\^e Gerencs\^er

Abstract:

In this talk we will see that the It\^o solutions of the nonlinear stochastic heat equation

$$\partial_t u^\varepsilon - \Delta u^\varepsilon = \varepsilon^{3/4} g(u^\varepsilon) \nabla \xi_\varepsilon,$$

where ξ_ε denotes the mollification in space at scale $\varepsilon > 0$ of a space-time white noise ξ , converge in law, as $\varepsilon \rightarrow 0$, to the solution of the stochastic heat equation with right-hand side $cg'(u)\xi$ with a constant $c > 0$. Since the noise $\nabla \xi$ is supercritical, the small prefactor is not unexpected to obtain a limit, but the exponent $3/4$ is not predicted by naive scaling arguments. The case $g(u) = u$, modulo a Cole-Hopf transform, corresponds to the result of Hairer (2025) for the KPZ equation. Our argument is relatively short and relies solely on stochastic analytic techniques.

Large deviations and weak solution concepts in a stochastic Galerkin-Euler system

Schedule: July 8 17:00-17:30 Room 438

Lucio Galeati

University of L'Aquila, Italy

Co-Author(s): Daniel Heydecker

Abstract:

Motivated by fluctuating hydrodynamics, modelling of turbulent fluids, and previous analysis of the Landau-Lifschitz-Navier-Stokes equations, we study a dynamical large deviation principle for solutions to a Galerkin approximation of the stochastic 3D Euler equations; here the noise is divergence free, of Stratonovich transport type, and we consider a scaling regime where the noise intensity ε and the inverse of the Fourier truncation parameter N go to zero simultaneously. We first show the validity of both a restricted lower bound and an upper bound on compact sets, for a natural choice of rate function, concerning L^2 -valued admissible weak solutions of the associated skeleton Euler equations. Exploiting the dynamical reversibility of the system, we then show the existence of energy inadmissible solutions, which must be seen by any extension of the rate function which results into a global LDP lower bound. Finally, we extend the LDP upper bound to a global one, by considering a newly introduced concept of H-measure-valued solutions to skeleton Euler. Based on joint work with Daniel Heydecker (Oslo).

Pathwise Solvability and Bubbling in 2D Stochastic Landau-Lifshitz-Gilbert Equations

Schedule: July 9 9:00-9:30 Room 438

Ben Goldys

Sydney University, Australia

Co-Author(s): Chunxi Jiao, Christof Melcher

Abstract:

We investigate the stochastic Landau-Lifshitz-Gilbert (LLG) equation on a periodic 2D domain, driven by infinite-dimensional Gaussian noise in a Sobolev class. We establish strong local well-posedness in the energy space and characterize blow-up at random times in terms of energy concentration at small scales (bubbling). By iteration, we construct pathwise global weak solutions, with energy evolving as a càdlàg process, and prove uniqueness within this class. These results offer a stochastic counterpart to the deterministic concept of Struwe solutions. The approach relies on a transformation that leads to a magnetic Landau-Lifshitz-Gilbert equation with random gauge coefficients.

The Leibenson process as a strong solution to its associated McKean--Vlasov SDE

Schedule: July 8 9:30-10:00 Room 438

Sebastian Grube

Bielefeld University, Germany

Co-Author(s): Viorel Barbu, Marco Rehmeier, Michael Roeckner

Abstract:

This talk continues the presentation by Marco Rehmeier. The Leibenson process, a nonlinear Markov process, is constructed from the path laws of probabilistically weak solutions to a class of McKean--Vlasov SDEs associated to the Leibenson equation. Despite the low regularity of the coefficients of these highly degenerate McKean--Vlasov SDEs, we can show that the weak solutions constituting the Leibenson process are, in fact, strong solutions. As a special case, we show that the p -Brownian motion is a strong solution to its associated McKean--Vlasov SDE.

The Porous Medium Equation: Multiscale Integrability in Large Deviations

Schedule: July 8 16:30-17:00 Room 438

Daniel Heydecker

University of Oslo, Norway

Co-Author(s): Benjamin Gess

Abstract:

We consider the large deviations of a particle system η^N with degenerate and superlinear diffusivity. The key challenge is to develop uniform integrability estimate on the nonlinearity $(\eta^N(x))^\alpha$ in a situation where neither pathwise regularity nor Dirichlet-form based regularity is readily available. This is resolved introducing a novel multiscale argument exploiting the appearance of pathwise regularity across scales.

Milstein-type Schemes for Hyperbolic SPDEs

Schedule: July 9 17:30-18:00 Room 438

Katharina Klioba

TU Delft, Netherlands

Abstract:

Discretisations of SPDEs with multiplicative noise in time that rely solely on the Wiener increments $W(t_{j+1}) - W(t_j)$ are known to converge at most at rate $1/2$. To overcome this limitation, one needs to consider higher-order terms from an Ito-Taylor expansion, leading to iterated stochastic integrals. The resulting Milstein scheme is well-studied for both SDEs and parabolic SPDEs. In this talk, convergence rates of the Milstein scheme are presented for hyperbolic SPDEs, where no smoothing effect over time can be leveraged. Optimal convergence rates are derived for the pathwise uniform strong error

$$E_h^\infty := (\mathbb{E} \max_{1 \leq j \leq M} \|U(t_j) - u_j\|_X^p)^{1/p}$$

on a Hilbert space X for $p \in [2, \infty)$. Here, U is the mild solution and u_j its Milstein approximation at time $t_j = jh$ with step size $h > 0$ and final time $T = Mh > 0$. For sufficiently regular nonlinearity and noise, we establish strong convergence of order one, with the error satisfying $E_h^\infty \leq h\sqrt{\log(T/h)}$ for rational Milstein schemes and $E_h^\infty \leq h$ for exponential Milstein schemes. This extends previous results from parabolic to hyperbolic SPDEs, from exponential to rational Milstein schemes, and from root-mean-square error estimates to pathwise uniform estimates. Applications include the stochastic Schroedinger and transport equations. This is joint work with Felix Kastner.

Variational Framework for SPDE: Old and New

Schedule: July 8 17:30-18:00 Room 438

Wei Liu

Jiangsu Normal University, Peoples Rep of China

Abstract:

In this talk we mainly present some recent progress on the variational framework for SPDE, especially on McKean-Vlasov SPDE and regularization effect by noise.

Strong uniqueness by Kraichnan transport noise for the inviscid 2D Boussinesq system

Schedule: July 9 8:30-9:00 Room 438

Dejun Luo

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

We consider the inviscid 2D Boussinesq system driven by rough transport noise of Kraichnan type with regularity index $\alpha \in (0, 1/2)$. For all $p > 1$, we establish the existence and uniqueness of probabilistic strong solutions for all L^p initial vorticity and L^2 initial temperature, under the parameter constraint $\alpha \in (0, 1 - 1/(p \wedge 2))$. The talk is based on a joint work with Dr. Shuaijie Jiao.

Ergodicity for SPDEs driven by divergence-free transport noise

Schedule: July 8 13:30-14:00 Room 438

Adrian Martini

Technical University of Berlin, Germany

Co-Author(s): Benjamin Gess, Rishabh S. Gvalani

Abstract:

We study the ergodic behaviour of McKean--Vlasov equations driven by common, divergence-free transport noise. In particular, we show that in dimensions greater or equal to 2, if the noise is mixing and sufficiently strong, it can enforce the uniqueness of invariant probability measures, even if the deterministic part of equation has multiple steady states. This is joint work with Benjamin Gess and Rishabh S. Gvalani.

The FBSDE approach to EQFTs

Schedule: July 9 15:00-15:30 Room 438

Sarah-Jean SJM Meyer

University of Oxford, England

Co-Author(s): Massimiliano Gubinelli

Abstract:

I will present recent progress on the forward-backward SDE (FBSDE) approach to Euclidean quantum field theories (EQFT), focusing on the example of the sine-Gordon model. The FBSDE describes the dynamics of transitioning between scales and can be viewed as a rigorous implementation of the renormalization group for the model, providing a powerful description of the interacting theory as a coupling with the Gaussian free field. Once established, the FBSDE is the starting point for a stochastic analysis of the EQFT to derive additional properties of the field, such as large deviations, decay of correlations, singularity, and a full verification of the Osterwalder-Schrader Axioms. I will outline the general construction of the stable reformulation and discuss ongoing work on the sine-Gordon model.

On modified stochastic Boussinesq-Benard equations in dimension 3

Schedule: July 8 8:00-8:30 Room 438

Annie A MILLET

University Paris 1 Pantheon Sorbonne, France

Co-Author(s): Hakima Bessaih

Abstract:

We study the Boussinesq-Benard equations in dimension 3 subject to a multiplicative random perturbation; we have to add a Brinkman-Fochheimer smoothing term in the evolution equation for the velocity u . We prove that for H^1 -initial velocity u_0 and temperature θ_0 with proper moments, the system of SPDEs is a.s. globally well posed in $(C([0, T]; H) \cap L^4(0, T; V)) \times (C([0, T]; L^2) \cap L^2(0, T; H^1))$. We also prove the existence of higher moments of the solution (u, θ) .

On the role of the maximum principle in high order approximations of the Dean-Kawasaki equation

Schedule: July 8 14:30-15:00 Room 438

Nicolas Perkowski

Free University Berlin, Germany

Abstract:

The Dean-Kawasaki equation was formally derived in the physics literature as a coarse-grained SPDE describing interacting particle systems on mesoscopic scales. However, as later discovered in the mathematics literature, it is really an exact rewriting of the particle system and does not allow for a coarse-graining interpretation. To go to mesoscopic scales, a posteriori truncations of the Dean-Kawasaki have been studied in recent years, and they have been shown to capture large deviations of the particle system, and the approximation error has been controlled quantitatively. In my talk, I will discuss the role of the maximum principle in such approximations: To obtain a superpolynomial approximation rate it seems necessary to consider approximations that violate the maximum principle. Those, however, are shown to achieve only a poor approximation if there is a ``vacuum`` i.e. spatial regions with no or very few particles. Joint work with Ana Djurdjevac.

The Leibenson equation and its associated nonlinear Markov process

Schedule: July 8 9:00-9:30 Room 438

Marco Rehmeier

TU Berlin, Germany

Co-Author(s): Viorel Barbu, Sebastian Grube, Michael Röckner

Abstract:

We construct a probabilistic counterpart for the Barenblatt solutions of the doubly nonlinear Leibenson equation $\partial_t u(t, x) = \Delta_p u^q(t, x)$, $(t, x) \in (0, \infty) \times \mathbb{R}^d$, where $\Delta_p f = \operatorname{div}(|\nabla f|^{p-2} \nabla f)$ denotes the p -Laplace operator, $p > 2$ and $q > 0$. This counterpart is a family of stochastic processes with one-dimensional time marginal densities given by the Barenblatt solutions. These processes are constructed as weak solutions to a McKean-Vlasov equation whose coefficients depend on the solution law pointwise via the gradient of its density. To this end, we first identify the Leibenson equation as a nonlinear Fokker-Planck equation. Moreover, we prove that these processes form a unique nonlinear Markov process with Barenblatt time marginals, which we call the Leibenson process. Joint work with Viorel Barbu, Sebastian Grube and Michael Röckner.

Boltzmann processes

Schedule: July 9 9:30-10:00 Room 438

Barbara Ruediger

University Wuppertal, Germany

Co-Author(s): Barbara Rüdiger, Padmanabhan Sundar

Abstract:

The Boltzmann equation describes the dynamics of a density in position and velocity of a rarified gas expanding in vacuum. Ludwig Eduard Boltzmann (1844 -1906) derived the Boltzmann equation, by assuming any gas molecule of a rarified gas to travel straight in vacuum until an elastic collision occurs with another molecule of the same gas. In the Boltzmann equation, only binary centered collisions are considered. In this talk we present the Boltzmann process \cite{ARS}, i.e the process whose density evolves according to the Boltzmann equation. Using the Ito formula, we prove that this is a solution of a stochastic differential equation of McKean Vlasov type, for which we prove the existence \cite{RS} \bibitem{ARS} Albeverio, S., Rüdiger B., Sundar P.: On the construction and identification of Boltzmann processes. In: Brascos S., Butta P., Cassandro M., Picco P., Vares M. E. (eds.), ENSAIOS MATEMATICOS, vol.38, pp. 1-22, . Papers in honor of Errico Presutti, Sociedade Brasileira de Mathematica (2023). \doi{10.21711/217504322023/em381.} \bibitem{RS} Rüdiger B., Sundar P.: .: Identification and existence of Boltzmann processes, arxiv 2301.08662v2 (2025). \doi{10.48550/arXiv.2301.08662}.

Mean-field games and Hamilton--Jacobi equations with nonlocal diffusions

Schedule: July 8 15:30-16:00 Room 438

Artur Rutkowski

Wrocław University of Science and Technology, Poland

Co-Author(s): Espen Jakobsen, Robin Lien

Abstract:

A mean-field game system is a system consisting of a backward Hamilton--Jacobi equation and a forward Fokker--Planck equation. It was proposed 20 years ago by Huang, Malham\`{e}, Caines, Lasry, and Lions, as a means to study large population games. We will discuss the well-posedness results for mean-field game systems and the classical solutions to associated master equations in the whole space $\mathbb{R}^d$, driven by individual L^{∞} noise of order $\alpha \in (1, 2]$, without a priori assuming the existence of any moments. We will also present a rather optimal way to express the order α of the noise in terms of the heat kernel of its generator. In this regime, we prove Schauder estimates for the Hamilton--Jacobi equations in the subcritical case $\alpha \in (1, 2]$, where the noise dominates the gradient nonlinearity, and we give partial results for the critical case $\alpha = 1$. Our results are purely deterministic, but extensions to the framework of SPDEs are possible and interesting. In this connection, we will briefly discuss mean-field games with common noise.

The incompressible Navier--Stokes--Fourier system with thermal noise

Schedule: July 9 8:00-8:30 Room 438

Max Sauerbrey

MPI MiS, Leipzig, Germany

Co-Author(s): Benjamin Gess, Zhengyan Wu

Abstract:

We establish a solution theory (global weak existence, local strong existence and weak-strong uniqueness) for the incompressible Navier--Stokes--Fourier system with thermal noise, posed on the three-dimensional torus. While in the incompressible deterministic setting the equation for the velocity u can be solved independently of the temperature ϑ , the inclusion of the effects of thermal fluctuations by means of the GENERIC framework leads to a nonlinear gradient noise term, which couples the dynamics of both variables. Therefore, the analysis of the system for (u, ϑ) poses new challenges, which are absent in deterministic Navier--Stokes--Fourier equations.

A priori bounds for stochastic porous media equations

Schedule: July 9 14:30-15:00 Room 438

Markus Tempelmayr

EPFL, Switzerland

Abstract:

We discuss a priori regularity estimates for solutions of stochastic porous media equations, in a regime where the equation is both singular and degenerate. For simplicity we consider only a mildly singular regime, which allows to prove modelledness of the solution with respect to the solution of the corresponding linear stochastic heat equation. If time permits we discuss some ingredients of the proof, including the kinetic formulation of the equation and a renormalized energy inequality.

Stochastic reaction diffusion equations with non-trace class noise

Schedule: July 9 16:30-17:00 Room 438

Mark Veraar

TU Delft, Netherlands

Co-Author(s): Antonio Agresti and Fabian Germ

Abstract:

In this talk, I will give an overview of recent results on stochastic reaction-diffusion equations driven by non-trace class noise. Specifically, I will highlight new developments regarding: critical spaces of initial values, novel regularization phenomena, and improved linear estimates for stochastic convolutions

Recent progress on stochastic Zakharov system: well-posedness theory and noise-regularization effect

Schedule: July 9 15:30-16:00 Room 438

Deng Zhang

Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

In this talk we will review some recent results on the well-posedness theory and noise-regularization effect for stochastic Zakharov system in dimensions $d \geq 3$. Our focus is particularly directed at the large data regime where the global existence and long-time dynamics of deterministic Zakharov system is largely open. The noise-regularization effect on scattering is proved up to borderlines dictated by the regularity threshold of noise. These works are in joint with Sebastian Herr, Michael Rockner, Martin Spitz and Zhenqi Zhao.

Special Session 12 : Propagation Phenomena in Reaction-Diffusion Systems

Organizer(s): Hirokazu Ninomiya , Masaharu Taniguchi

Introduction: This special session is concerned with mathematical analysis on propagation phenomena or pattern formation appearing in reaction-diffusion systems. Related topics are traveling waves, entire solutions and asymptotic behaviors of solutions in reaction-diffusion systems.

Regularity and long-time dynamics of some free boundary models: Successes and challenges

Schedule: July 6 13:30-14:00 Room 637

Yihong Du

University of New England (Australia), Australia

Abstract:

In 1937, independently, Fisher and KPP (Kolmogorov-Petrovskii-Piskunov) used a simple reaction-diffusion equation to model the spreading of a species, which is now known as the Fisher-KPP model. A striking feature of the model is that it predicts an asymptotic spreading speed (determined by an associated traveling wave solution). Such a phenomenon has been observed in many examples of species spreading in the real world, and was first rigorously proved by Aronson-Weinberger (1975), after which much further developments of the mathematical theory for propagation have been achieved along various lines. In this talk, I will focus on one aspect of some recent developments of this theory, which involves reaction-diffusion equations with free boundaries. I will discuss the longtime dynamics of these models and the associated regularity questions, including some success stories and challenges.

Propagation of opinions on a network. The Daley-Kendall model.

Schedule: July 7 14:30-15:00 Room 637

Romain Ducasse

LJLL, universite Paris Cité, France

Abstract:

We study a model designed to describe the spatial spread of opinions in a population. This model is based on the Daley-Kendall model for opinion propagation. It consists in a system of nonlinear integral equations, and shares some resemblances with the SIR model from epidemiology, in that it treats the transmissions of the opinions similarly to those of a virus. The crucial difference is that the Daley-Kendall has a nonlinear saturation term, that accounts for the stifling of the opinion. We consider the model set on a graph, so that the transmission and the stifling depend on the neighbour nodes. We study how the opinion propagates through the graph (convergence toward steady states, speed of propagation). We also show that, in some situations, the model converges toward pattern-like steady states.

Biological invasions in patchy landscapes: a reaction-diffusion model with interface conditions

Schedule: July 7 13:30-14:00 Room 637

Francois Hamel

Aix-Marseille University, France

Co-Author(s): Quentin Griette, Frithjof Lutscher, Mingmin Zhang, Min Zhao

Abstract:

In this talk, I will discuss a one-dimensional model for biological invasions in heterogeneous patchy landscapes. Each patch has a relatively well-defined structure which is considered as homogeneous, but coupling interface conditions are imposed between adjacent patches, incorporating patch preference data. In the case of two patches, I will mention various results on spreading, blocking, or virtual blocking phenomena when the per capita growth rates in the patches are maximal or on the contrary negative at low densities. I will also report on some propagation or extinction phenomena in the case of periodic patches involving bistable or monostable reactions. The talk is based on some joint works with Quentin Griette, Frithjof Lutscher, Mingmin Zhang and Min Zhao.

Rigorous Construction of Stop-and-Go Waves in the Optimal Velocity Model via a differential-difference equation

Schedule: July 6 16:30-17:00 Room 637

Kota Ikeda

Meiji University, Japan

Co-Author(s): Tomoyuki Miyaji

Abstract:

We investigate nonlinear wave structures in the Optimal Velocity (OV) model, a fundamental microscopic traffic flow model describing car-following dynamics on a circuit. By introducing a traveling-wave representation of vehicle headways, the original ordinary differential system is reduced to a difference-differential equation. We focus on steep optimal velocity functions close to a step function, which generate sharp transition layers in the headway profile. In the singular limit, explicit heteroclinic transition layer solutions connecting two uniform traffic states can be constructed. Motivated by related exactly solvable queue models in the literature, we rigorously prove the existence of heteroclinic traveling waves for sufficiently steep optimal velocity functions. We further establish the existence of homoclinic solutions formed by the interaction of increasing and decreasing transition layers and derive a necessary condition on the amplitude parameter for their existence. To construct periodic stop-and-go waves on a circuit, we impose a global constraint reflecting conservation of total road length. Within this constrained framework, we prove the existence of large-period periodic solutions consisting of alternating transition layers and quasi-uniform states. These results provide a rigorous foundation for nonlinear congestion wave patterns beyond local bifurcation analysis.

Spot solutions to a neural field equation on the sphere and spheroid

Schedule: July 6 17:30-18:00 Room 637

Hiroshi Ishii

Hokkaido University, Japan

Co-Author(s): Riku Watanabe

Abstract:

This talk deals with the Amari model, an integro-differential equation that is one of the fundamental neural field equations. Neural field equations are mathematical models used to analyze the time evolution of excitation patterns in neural fields and to understand the dynamics of neuronal populations at the tissue level. In recent years, increasing attention has been paid to the influence of the geometry of organs, such as the brain, on pattern formation, and to the constraints on solution behavior imposed by curved surfaces. To investigate such geometric effects, we consider the sphere and a slightly deformed sphere (spheroid) as model surfaces, and analyze how the structure and stability of spot solutions depend on the geometry of the surface. First, we construct spot solutions on the sphere and characterize their linear stability through spectral analysis of the linearized operator. Next, we perform a perturbation analysis from the sphere to construct spot solutions at the north pole of the spheroid and derive the eigenvalues that determine stability. Finally, numerical simulations based on the theoretical results are carried out to examine the behavior of spot solutions.

Classification and bifurcation structures of cross-diffusion limits in the SKT model

Schedule: July 6 14:00-14:30 Room 637

Kousuke Kuto

Waseda University, Japan

Co-Author(s): Yaping Wu

Abstract:

This talk concerns asymptotic regimes of positive steady states in the Shigesada-Kawasaki-Teramoto competition model under large cross diffusion limits. First, we present a systematic classification of limiting regimes according to unilateral or full cross diffusion limits together with boundary conditions including Neumann and Dirichlet cases. We explain how these four settings lead to distinct limiting shadow systems and determine qualitative structures of coexistence states such as segregation, extinction, or concentration profiles. This classification provides a unified framework that organizes previously known results and clarifies structural relations between different limiting procedures. Second, we analyze the unilateral cross diffusion limit with Neumann boundary conditions and describe bifurcation structures of large amplitude steady states near critical spectral thresholds. Combining spectral analysis, singular perturbation techniques, and reduction methods, we establish existence of solution branches and obtain precise descriptions of their asymptotic profiles and instability properties.

On the Shape of Expansion of a Population in the Presence of a Fast Road

Schedule: July 7 9:30-10:00 Room 637

King Yeung Lam

The Ohio State University, USA

Co-Author(s): Chris Henderson and King-Yeung Lam

Abstract:

We consider the road-field reaction-diffusion model introduced by Berestycki, Roquejoffre, and Rossi. By performing a thin-front limit, we deduce a Hamilton-Jacobi equation with a suitable effective Hamiltonian on the road that governs the front location in the road-field model. Our main motivation is to apply the theory of strong (flux-limited) viscosity solutions to obtain a control-theoretic interpretation of the front location. We then formulate the ecological invasion problem as one of finding optimal paths that balance the positive growth rate in the field with the fast diffusion on the road. Along the way, we extend the results of Berestycki et al. to conical domains and exhibit non-convex expansion shapes. We also provide a new proof of known results for the one-road half-space problem using our approach. This is joint work with Chris Henderson.

Traveling Waves for Burgers-Fisher-KPP Equations with Singularity

Schedule: July 6 14:30-15:00 Room 637

Ming Mei

Jiangxi Normal University, Peoples Rep of China

Abstract:

In this talk, I will present a recent study on Burgers-Fisher-KPP equation with singular slow/fast diffusion and singular/regular convection in the form of $u_t - D\Delta u^m + \alpha(u^p)_x = f(u)$ with $m, p > 0$, focusing on the existence, non-existence, regularity and stability of traveling waves. The values of m and p essentially affect the existence/non-existence of regular/sharp traveling waves as well as their regularity. By combining phase-plane analysis and variational techniques, we obtain a complete classification of existence/non-existence of regular/sharp traveling waves related to m and p . In the singular regimes with 0

Existence and stability of nontrivial solutions for bistable reaction-diffusion equations on graphs of finite length

Schedule: July 7 8:30-9:00 Room 637

Harunori Monobe

Osaka Metropolitan University, Japan

Co-Author(s): Yoshihisa Morita

Abstract:

In this study, we consider the existence and stability of steady-state solutions to reaction-diffusion equations with a bistable nonlinearity on a graph of finite length. In this presentation, we first consider a "star-graph" consisting of a single junction and show the existence and stability of non-constant steady-state solutions when the edge lengths are sufficiently large. We then use these results to show the existence and stability of non-constant steady-state solutions on more complex graphs. This is a joint work with Professor Yoshihisa Morita.

Propagation and blocking of driven curvature flow in a strip domain with periodic obstacles

Schedule: July 6 18:00-18:30 Room 637

Ryunosuke Mori

Meiji University, Japan

Abstract:

We study the long-time behavior of driven curvature flow in a strip domain with periodic obstacles. In this setting, solutions exhibit two distinct behaviors: propagation and blocking. This talk characterizes how geometric features of the domain determine which behavior occurs. In a strip domain with periodically undulating boundaries, Matano, Nakamura, and Lou (2006) characterized the long-time behavior of driven curvature flow in terms of the boundary geometry. They introduced the notion of a maximal opening angle to describe the conditions for propagation, blocking, and the propagation speed, under which global-in-time graph-like classical solutions exist. Later, Matano and Mori extended this analysis to more general settings where such classical solutions may fail to exist, and proposed the concept of an effective opening angle to characterize propagation and blocking phenomena. In a strip domain with periodic obstacles, we introduce the notions of left and right opening angles, which are analogous to the effective opening angle. A key difference from previous studies lies in the propagation speed: while it is uniquely determined in earlier works, it is no longer unique in our setting.

An eco-epidemiological model with prey taxis and slow diffusion

Schedule: July 7 14:00-14:30 Room 637

Rana Parshad

Iowa State University, USA

Abstract:

In this work we analyze the effects of prey-taxis on the existence of global-in-time solutions and dynamics of an eco-epidemiological model. In particular, we consider the influence of slow dispersal characterized by the p -Laplacian operator, and enhanced mortality of the infected prey. Our results have large scale applications to biological invasions and biological control of pests.

Traveling waves and propagating terraces in gravitational fingering phenomena

Schedule: July 6 17:00-17:30 Room 637

Iuliia Petrova

University of Sao Paulo (USP), Brazil

Co-Author(s): Sergey Tikhomirov, Yalchin Efendiev

Abstract:

In the talk we will discuss the gravitational fingering phenomenon - the unstable displacement of miscible liquids in porous media with the speed determined by Darcy's law. Laboratory and numerical experiments show the linear growth of the mixing zone, and we are interested in determining the exact speed of propagation of fingers. We consider two models: Incompressible Porous Medium equation (IPM) and Transverse Flow Equilibrium (TFE). The existing theoretical upper bounds for the growth rate of the mixing zone (see e.g. Otto-Menon, 2005) are higher than the observed speed from the numerical simulations. We believe that one of the possible mechanisms of slowing down the fingers' growth is due to convection in the transversal direction, and explain it by introducing a semi-discrete model of IPM and TFE. The model consists of a system of advection-reaction-diffusion equations on concentration, velocity and pressure in several vertical tubes (real lines) and interflow between them. In the simplest setting of two tubes we show the structure of gravitational fingers - the profile of propagation is characterized by two consecutive travelling waves which we call a terrace. We prove the existence of such a propagating terrace for the parameters corresponding to small distances between the tubes. The main tool used in the proof is geometric singular perturbation theory (Fenichel) together with invariant manifold theory (Hirsch-Pugh-Shub). The questions of well-posedness of the model and stability of traveling waves are open, and I will be happy for any advice in this direction. The talk is based on joint work with S. Tikhomirov and Ya. Efendiev (SIMA, arXiv:2401.05981).

Threshold phenomena in local and nonlocal bistable reaction-diffusion equations

Schedule: July 7 9:00-9:30 Room 637

Lionel Roques

INRAE, France

Abstract:

Threshold phenomena are a basic feature of bistable reaction-diffusion equations. They refer to the existence of critical initial data separating extinction from invasion, with convergence to a ground state at the threshold. I will first discuss the classical local case $\partial_t u = \partial_{xx} u + f(u)$, with emphasis on the role of the amplitude and the spatial arrangement of the initial condition, in particular through fragmentation effects. I will then turn to a nonlocal equation of the form $\partial_t u = \partial_{xx} u + r(x)u - u \int_{\mathbb{R}} u - h(u)$, where the threshold structure appears to be richer and may involve two distinct thresholds.

Invasion shape for nonlocal KPP equations with metric diffusion kernels

Schedule: July 7 15:00-15:30 Room 637

Luca Rossi

Sapienza University of Rome, Italy

Abstract:

In this talk, we present some recent results obtained in collaboration with M. Alfaro and L. Du regarding the propagation in non-local Fisher-KPP equations with asymmetric convolution kernels. Our focus is on kernels that depend on a given norm, and we address the following natural geometric question: does the asymptotic invasion shape coincide with the ball corresponding to that norm? Contrary to what one might expect, the answer is generally negative. In fact, the shape of the invasion set (and not just its size) is the result of a non-trivial interplay between the kernel and the reaction term. The geodesic ball is only obtained in the limit as the reaction term tends to infinity. The arguments rely on a careful analysis of the regularity and geometric properties of the Wulff shape provided by the Freidlin-Gartner formula.

Reaction-Diffusion Model for Pattern Formation in Tape Peeling

Schedule: July 7 15:30-16:00 Room 637

Keisuke K Taga

Tokyo University of Science, Japan

Co-Author(s): Keisuke Taga

Abstract:

Depending on the peeling velocity, the traces formed on the surface of adhesive tape exhibit a variety of patterns. At an intermediate peeling velocity, a random fractal pattern resembling a Sierpiński gasket is observed. Several models have been proposed to explain this pattern formation. In this talk, we introduce our model, formulated as a reaction-diffusion system. The model is constructed by describing the tape-peeling dynamics as an excitable oscillatory system and incorporating spatial interactions arising from viscoelasticity together with a stochastic term. It has the form of a Liénard system and, under an appropriate transformation, can be related to a Bonhoeffer--van der Pol type reaction-diffusion system, which is known to exhibit Sierpiński-gasket patterns. We will also present results on the dynamical scaling properties of this model.

Reaction-diffusion approximation for nonlocal interactions

Schedule: July 6 15:00-15:30 Room 637

Yoshitaro Tanaka

Future University Hakodate, Japan

Co-Author(s): Hiroshi Ishii

Abstract:

In this talk, we study the mathematical relationship between nonlocal interactions of convolution type and systems of multiple diffusive substances in high-dimensional space. Motivated by the observation that nonlocal evolution equations can reproduce similar patterns to those arising in reaction-diffusion systems, we approximate nonlocal interactions in evolution equations by solutions to appropriate reaction-diffusion systems with multiple components in Euclidean space of arbitrary dimension. It is shown that any absolutely integrable radial kernel can be approximated by a linear combination of specific Green functions to elliptic partial differential equations. This enables us to demonstrate that a linear sum of auxiliary diffusive substances can approximate a broad class of nonlocal interactions of convolution type. Our results establish a connection between a broad class of nonlocal interactions and diffusive chemical reactions in dynamical systems.

Global existence for mass controlled reaction-diffusion systems

Schedule: July 6 15:30-16:00 Room 637

Bao Q Tang

University of Graz, Department of Mathematics and Scientific Computing, Austria

Abstract:

In this talk I discuss some recent advances on global existence of reaction-diffusion systems, where only natural assumptions such as quasi-positivity and mass controlled are imposed. It is shown that, in the case of smooth diffusion, the system with quadratic growing nonlinearities has a unique global classical solution, which is also bounded uniformly in time provided that the mass is dissipated. For non-smooth diffusion coefficients, the global existence of bounded weak solutions is shown by a generalised L^p -energy method and intermediate sum condition with sub-critical growth of nonlinearities.

Special Session 13 : Hyperbolic Partial Differential Equations and Applications

Organizer(s): Yachun Li , Ronghua Pan , Yue-Jun Peng

Introduction: The aim of this special session is to bring together experts in the area of partial differential equations to present their recent research results in theoretical analysis of hyperbolic PDEs and applications in some related fields like fluid dynamics. In this session, people are expected to exchange new ideas, to discuss challenging issues, to explore new directions and topics, and to foster new collaborations and connections.

Blow-up mechanism for 2-D compressible MHD equations with radial symmetry

Schedule: July 8 14:00-14:30 Room 637

Lv Cai

Shanghai University, Peoples Rep of China

Co-Author(s): Liu Jianli, Sheng Wancheng

Abstract:

We investigate the gradient blow-up mechanism of classical solution to the initial value problem of radially symmetric MHD equations in two spatial dimensions, where the inhomogeneity caused by polar radius brings new difficulties in the high-dimensional problem. By developing delicate estimates for the Riemann variables with coupling effects introduced by the magnetic field, we first obtain the upper bound for the solution itself under compressive initial conditions. Furthermore, we also get the blow-up of first derivatives of solution by constructing the Riccati equations. This generalizes the result of G. Chen, R. Young and Q. Zhang's work for 1-D MHD with orthogonal magnetic field [J. Hyperbolic Differ. Equ. 10 (2013), 149-172].

Local-in-time well-posedness for the regular solution to the 2D full compressible Navier-Stokes equations with degenerate viscosities and heat conductivity

Schedule: July 8 9:30-10:00 Room 637

Yue Cao

East China University of Science and Technology, Peoples Rep of China

Co-Author(s): Xun Jiang

Abstract:

We consider the two-dimensional Cauchy problem of the full compressible Navier-Stokes equations with far-field vacuum in $\mathbb{R}^2$, where the viscosity and heat-conductivity coefficients depend on the absolute temperature θ in the form of θ^ν with $\nu > 0$. Due to the appearance of the vacuum, the momentum equation are both degenerate in the time evolution and spatial dissipation, which makes the study on the well-posedness challenging. By establishing some new singular-weighted (negative powers of the density ρ) estimates of the solution, we establish the local-in-time well-posedness of the regular solution with far-field vacuum in terms of ρ , the velocity u and the entropy S . Moreover, the uniform regularity of the entropy S in $\mathbb{R}^2$ is established, i.e., $S - \bar{S} \in C([0, T]; H^3(\mathbb{R}^2))$ for some constant $\bar{S}$.

Singularity Formation for Supersonic Inward Wave of Radially Symmetric Euler Equations with Damping

Schedule: July 7 18:00-18:30 Room 637

Haitong Li

Changchun University of Technology, Peoples Rep of China

Co-Author(s): Jiabin Li, Qiang Zou

Abstract:

This talk focuses on the singularity formation for smooth solutions to the compressible radially symmetric Euler equations with damping. A smooth solution is called a supersonic inward wave if it satisfies $u < -h < 0$. For polytropic gases with $\gamma \geq 3$, the damping term introduces additional negative contributions into the evolution equations, which significantly modifies the structure of the corresponding Riccati type inequalities and accelerates the growth of gradients. By applying the characteristic method and constructing suitable invariant domains which different from the case of expanding wave, we prove that smooth supersonic inward solutions with sufficiently strong initial compression must develop singularity in finite time. Furthermore, an explicit upper bound for the lifespan of solutions is derived, which quantitatively characterizes the blowup mechanism of inward wave under damping. This work develops the studies by G. Chen et al. (arXiv: 2511.15180, 2025).

Non-uniqueness of weak solutions for the hypo-viscous compressible Navier-Stokes equations

Schedule: July 8 14:30-15:00 Room 637

Yachun Li

Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

We study the Cauchy problem for the isentropic hypo-viscous compressible Navier-Stokes equations under general pressure laws. By using convex integration method we provides the first non-uniqueness result of weak solutions to viscous compressible fluid. Due to the difficulties caused by the relative rigidity of the pressure and by the viscosity, our proof features new constructions of building blocks for both the density and momentum, which are, particularly, designed to respect the compressible structure. We provide first applications of a temporally intermittent but spatially homogeneous building block scheme and a mild density perturbation. It also applies to the compressible Euler equations and the hypo-viscous incompressible Navier-Stokes equations. This is a joint work with Peng Qu, Zirong Zeng, and Deng Zhang.

Formation of singularities for the relativistic membrane equation with radial symmetry

Schedule: July 8 8:30-9:00 Room 637

Jianli Liu

Shanghai university, Peoples Rep of China

Abstract:

The relativistic membrane equation can be rewritten as a first order hyperbolic system. Making use of the characteristic decomposition method, a new blow-up theorem is established. It demonstrates the formation of singularities for the relativistic membrane equation. Indeed, the singularity occurs when the hypersurface turns from being timelike to being null. This work is cooperated with Dr. Cai Lv of Shanghai University.

Stability of viscous shock for Burgers equations with double singularities in viscosity and flux

Schedule: July 8 13:30-14:00 Room 637

Ming Mei

Jiangxi Normal University, Peoples Rep of China

Abstract:

This talk is concerned with Burgers equation with singular viscosity and singular flux. We realize that, when the singularity for flux is less than the singularity of viscosity, there exists smooth viscous shock wave, otherwise the shock wave does not exist. The main issue is to show the stability of these shock waves. To overcome the singularities caused by viscosity and flux, we use the weighted energy method, where the selection of weights are technical and play a crucial role in the proof.

Rayleigh-Taylor instability and beyond

Schedule: July 7 16:30-17:00 Room 637

Ronghua Pan

Georgia Institute of Technology, USA

Abstract:

It is known in physics that steady state of fluids under the influence of uniform gravity is stable if and only if the convection is absent. In the context of incompressible fluids, convection happens when heavier fluids is on top of lighter fluids, known as Rayleigh-Taylor instability. However, in real world, heat transfer plays an important role in convection of fluids, such as the weather changes, and or cooking a meal. In this context, the compressibility of the fluids becomes important. Indeed, using the more realistic model of compressible flow with heat transfer, the behavior of solutions is much closer to the real world and more complicated. We will discuss these topics in this lecture, including some on-going research projects.

Supersonic reacting jet flows from a three-dimensional conical nozzle

Schedule: July 7 17:00-17:30 Room 637

Wancheng Sheng

Shanghai University, Peoples Rep of China

Abstract:

We study supersonic reacting jet flows from a three dimensional (3D) divergent conical nozzle. The flow is governed by 3D steady Zeldovich-von Neumann-Döring combustion equations with cylindrical symmetry and that the state of the flow is given at the inlet of the nozzle. When the nozzle is surrounded by a vacuum, a global continuous and piecewise smooth supersonic reacting jet flow expanding into the vacuum from the nozzle is obtained. When the nozzle is surrounded by a static atmosphere with a lower pressure than the pressure of the flow at the exit of the nozzle, we obtained a local continuous and piecewise smooth supersonic reacting jet flow expanding into the atmosphere from the nozzle. Moreover, an explanation for the formation of intercepting shocks in supersonic jets expanding into a lower pressure environment is shown, which is stated in the book *Supersonic Flow and Shock Waves* and is verified by physical experiments. The flow patterns constructed in the paper may be used as background solutions for more general supersonic jet flow problems. This work is jointed with Prof. G.Lai.

Study of fluid equations in non-smooth domains

Schedule: July 8 8:00-8:30 Room 637

Yaguang Wang

Shanghai Jiao Tong University, Peoples Rep of China

Co-Author(s): WANG Yaguang

Abstract:

In this talk, we shall study the well-posedness of the initial boundary value problem for the two-dimensional compressible ideal magnetohydrodynamic equations with the impermeable and perfectly conducting boundary conditions in domains with corners. Meanwhile, the small viscosity limit of viscous flow in quarter space will also be investigated. It is based on joint works with Wen Guo.

Global existence of large solutions to the 3D full compressible Navier-Stokes equations with temperature-dependent coefficients and vacuum

Schedule: July 8 9:00-9:30 Room 637

Shang Zhaoyang

Shanghai Lixin University of Accounting and Finance, Peoples Rep of China

Co-Author(s): Yachun Li, Peng Lu, Wei Xiang

Abstract:

It is well known that the global well-posedness of the Navier-Stokes equations with temperature-dependent coefficients is a challenging problem, especially in multi-dimensional space. In this talk, we study the 3D Navier-Stokes equations with temperature-dependent coefficients in the whole space, and establish the first result on the global existence of large strong solution when the initial density and the initial temperature are linearly equivalent to some large constant states. Moreover, the optimal decay rates of the solution to its associated equilibrium are established when the initial data belong to $L^{p_0}(\mathbb{R}^3)$ for some $p_0 \in [1, 2]$.

Global small solutions to the 2D non-resistive compressible MHD system near an equilibrium

Schedule: July 7 17:30-18:00 Room 637

Yi Zhu

East China University of Science and Technology, Peoples Rep of China

Abstract:

This talk focuses on the compressible magnetohydrodynamic (MHD) equations without magnetic diffusion in $\mathbb{R}^2$. We present a systematic approach to establish the global existence of smooth solutions when the initial data is close to a background magnetic field. To overcome key challenges arising from anisotropy and the critical nature of the system, we fully exploit the underlying dissipative structure and introduce several delicately constructed dissipative quantities. Compared with previous works, we solve this problem by pure energy estimates without extra help from Sobolev spaces of negative index.

Special Session 14 : New perspectives in the qualitative study of nonlinear differential equations and dynamical systems

Organizer(s): Andrea Tellini , Guglielmo Feltrin

Introduction: This special session aims to gather researchers in different topics related to nonlinear differential equations, dynamical systems and their qualitative study, from a theoretical perspective. The methodologies explored may include, but are not limited to, topological approaches, comparison techniques, variational methods, and fixed point theory. By presenting several points of view to closely related topics, this session is intended to stimulate discussions and provide valuable insights for future research.

Which diffusion strategy is best for a prey and a predator moving with Fractional Laplacians?

Schedule: July 8 15:30-16:00 Room 824

Elisa Affili

Universite de Rouen Normandie, France

Co-Author(s): Serena Dipierro, Giovanni Giacomini, Enrico Valdinoci

Abstract:

We consider a predator and a prey moving with Fractional Laplacians, letting the predator and the prey free to choose the exponent characterising the distribution of the jump lengths. Which exponent should the predator use to maximise its chance to catch the prey? And which one should the prey select to minimise the possibility of meeting the predator? In this talk, we study a functional that describes the chance of meeting taking into account both strategies. We focus in particular on the case of a large initial distance and we find ranges for the parameter of fractional diffusion corresponding to the maximum (for the predator) and the minimum (for the prey) in dependence of the choice of the other species. These findings rely on very fine estimates of the fundamental solution of the fractional heat equation.

Continuation theorems for periodic systems with nonlinear time-dependent differential operators

Schedule: July 7 17:30-18:00 Room 824

Pierluigi Benevieri

University of São Paulo, Brazil

Co-Author(s): Guglielmo Feltrin

Abstract:

The talk proposes some continuation theorems for the periodic problem
$$\begin{cases} x_{i+1}' = g_i(t, x_{i+1}), & i=1, \dots, n-1, \\ x_n' = h(t, x_1, \dots, x_n), \\ x_i(0) = x_i(T), & i=1, \dots, n, \end{cases}$$
 providing a unified framework that improves and extends earlier contributions by Jean Mawhin and collaborators to second-order differential problems governed by nonlinear time-dependent differential operators of the form
$$\begin{cases} (\phi(t, x'))' = f(t, x, x'), \\ x(0) = x(T), \quad x'(0) = x'(T). \end{cases}$$
 The proof is based on the topological degree theory. This is a joint work with Guglielmo Feltrin, University of Udine, Italy.

Non-smooth critical point theory: from relativistic celestial mechanics to symmetry breaking in PDEs

Schedule: July 7 16:30-17:00 Room 824

Alberto Boscaggin

University of Turin, Italy

Co-Author(s): Walter Dambrosio and Duccio Papini; Francesca Colasuonno, Benedetta Noris, Federica Sani and Tobias Weth

Abstract:

I will briefly discuss two problems on which I have been working in the last few years: the first is the periodic problem for systems of ODEs in relativistic mechanics, the second is the Dirichlet problem for supercritical elliptic PDEs. Although seemingly unrelated, these two problems have in common the fact that they are addressed through the non-smooth critical point theory developed since the seminal paper by Szulkin in 1986. I will try to highlight similarities and differences between the two applications. Based on joint works with Walter Dambrosio and Duccio Papini (systems of ODEs) and Francesca Colasuonno, Benedetta Noris, Federica Sani and Tobias Weth (elliptic PDEs).

Existence of a periodic solution for planar systems with possible finite-time blow-up

Schedule: July 8 8:30-9:00 Room 824

Alberto Cagetta

Università degli Studi di Udine, Italy

Co-Author(s): Paolo Gidoni

Abstract:

Periodic solutions for superlinear planar systems have been extensively studied, in particular in the Hamiltonian setting, for instance in the work of A. Boscaggin (2012). Such results typically rely on the global existence of solutions, a structural assumption whose role was clarified by P. Gidoni (2023) for a class of superlinear second-order equations where global existence may fail. In this paper we extend the results of Gidoni (2023) to general non-autonomous T -periodic planar systems of the form $\dot{z} = F(t, z)$ without assuming global forward existence of solutions. Under suitable asymptotic bounds on the rotation number of solutions, we prove the existence of at least one T -periodic solution. In the Hamiltonian case $F(t, z) = J\nabla_z H(t, z)$, we further investigate super-quadratic systems and provide explicit sufficient conditions ensuring that the rotational assumptions are satisfied. This is a joint work with Paolo Gidoni (University of Udine).

Optimizing vaccine allocation in an age-structured SIR model

Schedule: July 8 15:00-15:30 Room 824

Romain Ducasse

LJLL, universite Paris Cite, France

Co-Author(s): Luis Almeida, Elisa Paparelli

Abstract:

The SIR model is a nonlinear differential system that describes the spread of a disease in a population. In this talk, I will present an optimization problem where the goal is to maximize the final state of a SIR model by controlling a vaccination term : in other terms, we study how to optimize the allocation of vaccines during an epidemic in order to minimize the casualties. Our model is an heterogeneous nonlinear integral system with an age structure and with a control (the vaccination). Using adequate comparison principles, we manage to identify in some cases an optimal vaccination strategy.

A delay-induced nonlocal free boundary problem

Schedule: July 8 14:30-15:00 Room 824

Jian Fang

Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Yihong Du, Ningkui Sun

Abstract:

Incorporating time delay and Stefan type free boundary condition into reaction-diffusion equation yields a nonlocal problem. Under the KPP type setting we establish a dichotomy on propagation or vanishing. When propagation happens, the spreading speed is shown to exist and it is determined nonlinearly by a delay-induced nonlocal elliptic problem in half line.

Limit cycle and asymptotic gait for a dynamic model of rectilinear locomotion

Schedule: July 8 17:30-18:00 Room 824

Paolo Gidoni

University of Udine, Italy

Abstract:

Biological and bio-inspired locomotion is usually described by recognizing periodic patterns, or gaits, in the movement of limbs or other body parts. But is the evolution of the system actually periodic? Or more properly, relative-periodic, since, presumably, each cycle will propel the animal (or robot) a little bit forward? The answer is often no, due, for instance, to inertia or elasticity. However, we might expect the behaviour to converge asymptotically to a relative-periodic one. In this talk we will introduce this issue considering, as a case study, a dynamic model of rectilinear crawling locomotion. We study the existence of a global periodic attractor for the reduced dynamics of the model, corresponding to an asymptotically relative-periodic motion of the crawler. The main result is of Massera-type, namely we show that the existence of a bounded solution implies the existence of the global periodic attractor for the reduced dynamics. Additional conditions and a counterexample for the existence of a bounded solution (and therefore of the attractor) will be briefly discussed. We conclude surveying the issue for some related models.

Propagating terraces in periodic media

Schedule: July 8 13:30-14:00 Room 824

Thomas Giletti

University Clermont-Auvergne, France

Co-Author(s): Luca Rossi

Abstract:

In this talk, we will be interested in the propagation of solutions of a multistable reaction-diffusion equation in spatially periodic media. We will prove the existence of a so-called propagating terrace, which is a finite sequence of fronts whose speeds are ordered. These correspond to a situation where successive transitions occur between intermediate steady states. We will see that propagating terraces dictate the large-time behavior of solutions of the Cauchy problem, but also that new difficulties arise from the interplay between the different directions of propagation.

Rotating spirals and bifurcation analysis for competition systems

Schedule: July 8 16:30-17:00 Room 824

Zaizheng Li

Hebei Normal University, Peoples Rep of China

Co-Author(s): Susanna Terracini

Abstract:

In this talk, we mainly discuss the existence of rotating spirals for competition-diffusion systems and related bifurcation results. For the Neumann problem, we establish the existence of unstable rotating spirals by applying the multi-parameter bifurcation theorem. In addition, for the non-homogeneous Dirichlet problem, the Rothe fixed point theorem is employed to prove the existence of rotating spirals. And we will deliver some bifurcation analysis for the stationary problem. This talk is based on joint works with Prof. Susanna Terracini.

Global multiplicity results in a Moore-Nehari type problem

Schedule: July 7 18:30-19:00 Room 824

Eduardo Muñoz-Hernández

Complutense University of Madrid, Spain

Co-Author(s): Julián López-Gómez and Fabio Zanolin

Abstract:

In this talk, we present a superlinear problem of the Moore-Nehari type. If there is a general non-negative weight in front of the nonlinear term, existence of positive and nodal solutions is guaranteed by classical bifurcation methods. On the other hand, if we restrict ourselves to the analysis of positive solutions for a symmetric non-negative weight vanishing in the middle interval, i.e., to the classical setting of the Moore-Nehari problem, it is possible to prove multiplicity of positive solutions for both signs of the bifurcation parameter. This is a joint work with Professors Julián López-Gómez (Complutense University of Madrid) and Fabio Zanolin (University of Udine).

Bifurcation from periodic solutions of central force problems in the three-dimensional space

Schedule: July 7 17:00-17:30 Room 824

Duccio Papini

University of Modena and Reggio Emilia, Italy

Co-Author(s): Alberto Boscaggin, Guglielmo Feltrin

Abstract:

The talk deals with electromagnetic perturbations of a central force problem. The considered differential operator includes, as special cases, the classical one as well as that of special relativity. We investigate whether non-circular periodic solutions of the unperturbed problem can be continued into periodic solutions for small perturbations, both for the fixed-period problem and, if the perturbation is time-independent, for the fixed-energy problem. The proof is based on an abstract bifurcation theorem of variational nature, which is applied to suitable Hamiltonian action functionals. In checking the required nondegeneracy conditions we take advantage of the existence of partial action-angle coordinates as provided by the Mishchenko--Fomenko theorem for superintegrable systems. Physically relevant problems to which our results can be applied are homogeneous central force problems in classical mechanics and the Kepler problem in special relativity.

Liouville-type results for the Fisher-KPP equation: old and new

Schedule: July 8 14:00-14:30 Room 824

Luca Rossi

Sapienza University of Rome, Italy

Abstract:

In this talk, we present a joint work with O. Trough on the existence and uniqueness of positive bounded stationary solutions to the Fisher-KPP equation in unbounded domains, with Dirichlet boundary conditions. Under strong KPP-type assumptions, we derive a necessary and sufficient condition for existence in dimensions ≤ 6 , expressed in terms of the generalized principal eigenvalue. We further show that, whenever it exists, the solution is unique. As an application, one infers that for branching Brownian motion, global survival implies local survival in low dimensions.

Large positive solutions for a class of 1-D diffusive logistic problems with general boundary conditions

Schedule: July 8 9:00-9:30 Room 824

Alejandro Sahuquillo

Universidad Complutense de Madrid, Spain

Co-Author(s): Julián López-Gómez and Andrea Tellini

Abstract:

The first goal of this paper is to establish the existence of a positive solution for the singular boundary value problem (1.1), where $\mathcal{B}$ is a general boundary operator of Dirichlet, Neumann or Robin type, either classical or non-classical, not necessarily of Sturm--Liouville type. Since $f(u) := au^p - \lambda u$, $u \geq 0$, is not increasing if $\lambda > 0$, the uniqueness of the positive solution is not obvious, even when $a(x)$ is a positive constant. The second goal of this paper is to establish the uniqueness of the positive solution of (1.1) in that case. At a later stage, denoting by L_λ the unique positive solution of (1.1) when $a(x)$ is a positive constant, we will characterize the point-wise behavior of L_λ as $\lambda \rightarrow \pm\infty$. Finally, we establish the uniqueness of the positive solution of (1.1) when $a(x)$ is non-increasing in $[0, R]$, $\lambda \geq 0$, and $\beta < 0$ if $-u'(0) + \beta u(0) = 0$. This is a joint work with Julián López-Gómez and Andrea Tellini.

Reaction--diffusion systems with degenerate diffusivity: wavefronts and their qualitative properties

Schedule: July 8 17:00-17:30 Room 824

Elisa Sovrano

University of Modena and Reggio Emilia, Italy

Abstract:

We consider a system of two coupled reaction--diffusion equations in which one component is governed by doubly degenerate diffusion. These systems do not preserve the total mass, separating them from standard scalar reaction-diffusion equations. We investigate the existence and qualitative properties of wavefront solutions, namely profiles that propagate with constant speed and are represented by a pair of strictly monotone functions. Using a combination of shooting techniques and fixed-point arguments, we derive conditions ensuring the existence of wavefronts and obtain estimates for threshold speeds. We also address the regularity of the wavefront profiles and discuss the possible occurrence of sharp wavefronts arising from diffusion degeneracy. The model arises in the study of the spatio-temporal evolution of bacterial colonies growing on nutrient-rich agar substrates. Joint work with L. Malaguti, V. Taddei (University of Modena and Reggio Emilia), and E. Muñoz-Hernández (Complutense University of Madrid).

Morse index and symmetry-breaking bifurcation of positive solutions for the one-dimensional Liouville type equation with a step weight

Schedule: July 7 18:00-18:30 Room 824

Satoshi Tanaka

Tohoku University, Japan

Co-Author(s): Satoshi Tanaka

Abstract:

We consider the boundary value problem $u'' + \lambda h(x, \alpha)e^u = 0$ for $x \in (-1, 1)$; $u(-1) = u(1) = 0$, where λ is a positive parameter, $\alpha \in (0, 1)$, $h(x, \alpha) = 0$ for $x \in (-\alpha, \alpha)$, and $h(x, \alpha) = 1$ for $\alpha \leq |x| \leq 1$. We compute the Morse index of positive even solutions, and then we prove the existence of an unbounded connected set of positive non-even solutions emanating from a symmetry-breaking bifurcation point. This is a joint work with Kanako Manabe (JG Corporation).

Nodal solutions for the Minkowski mean curvature operator: multiplicity and large-

mu

asymptotics

Schedule: July 8 9:30-10:00 Room 824

Ricardo Ziegele

Universit  degli studi di Torino, Italy

Co-Author(s): Alberto Boscaggin, Francesca Colasuonno

Abstract:

We study the Dirichlet problem for the mean curvature operator in Minkowski space on a bounded domain $\Omega \subset \mathbb{R}^n$. For this problem, we study the interaction between two parameters (λ, μ) and their effects on the multiplicity of nodal solutions. In the general setting, using non-smooth variational methods, we prove the existence of a ground-state solution and a linking solution. In the radial case, we prove existence and multiplicity of nodal solutions. Finally, we characterize the limiting profile of these solutions in both settings as $\mu \rightarrow +\infty$. This is a joint work with Alberto Boscaggin (Universit  di Torino) and Francesca Colasuonno (Universit  di Torino).

Special Session 15 : Qualitative properties for solutions to nonlinear elliptic and parabolic equations

Organizer(s): Wenxiong Chen , Yahong Guo , Congming Li

Introduction: We will discuss and share insights into recent developments regarding the qualitative properties of solutions to nonlinear elliptic and parabolic equations, including fractional equations. These properties includes, but not limited to, symmetry, monotonicity, uniqueness, nonexistence, regularity, a priori estimates, and existence of solutions.

Regularity for Local-Nonlocal Elliptic Equations with (p, q) -Growth and Matrix Weights

Schedule: July 8 8:30-9:00 Room 316

Sun-Sig Byun

Seoul National University, Korea

Abstract:

This talk studies mixed local and nonlocal elliptic equations with degenerate and singular matrix weights. Using a frozen-weight comparison method, we obtain higher integrability and gradient estimates while addressing intrinsic geometry and nonlocal tail effects.

Stability of Sobolev inequality and Sobolev equation in the endpoint case.

Schedule: July 7 15:30-16:00 Room 316

Lu Chen

Beijing Institute of Technology, Chile

Abstract:

In this talk, I will first revisit some new progress on the optimal stability of geometric inequality including Sobolev inequality, HLS inequality and fractional Sobolev inequality etc. Then I will present our recent results on the stability of Sobolev inequality and Sobolev equation in the end-point case. Finally, I will explain the relationship between these quantitative stability inequality and Aubin` conjecture, Chang-Yang conjecture, Keller-Segel equation

Monotonicity for solutions to a fractional nonlinear problem in a half space

Schedule: July 8 14:30-15:00 Room 316

Wenxiong Chen

Yeshiva University, USA

Co-Author(s): Yahong Guo, Leyun Wu

Abstract:

We study nonlinear fractional equations

$$(-\Delta)^s u(x) = f(u(x))$$

in a half-space and prove that all positive solutions are strictly increasing in the x_n -direction. Previous results typically require the solution u to be globally bounded in $\mathbb{R}^n$. We substantially weaken this condition by assuming only that u be bounded in each slab. As a crucial ingredient, we obtained a boundary Hölder regularity estimate that requires only the boundedness of u near the boundary. This represents a significant improvement over existing results, which often assumed global boundedness of u throughout $\mathbb{R}^n$. To derive the monotonicity, we employ the method of moving planes. We first obtain a narrow region principle in unbounded domains, then we apply averaging effects four times to ensure that the planes can be moved continuously all the way to $x_n = \infty$. Compared with the traditional approaches, methods based on this new technique-the averaging effect require substantially weaker regularity assumptions and can even accommodate unbounded solutions.

Non-radial solutions for the critical quasi-linear Henon equation

Schedule: July 7 9:30-10:00 Room 316

Wei Dai

Beihang University (BUAA), Peoples Rep of China

Co-Author(s): Lixiu Duan, Changfeng Gui, Yuan Li

Abstract:

In this talk, we show the existence of non-radial solutions for the critical quasi-linear Henon equation involving p -Laplace operator (\$1

Global wellposedness for the Muskat problem

Schedule: July 7 8:30-9:00 Room 316

Hongjie Dong

Brown University, USA

Abstract:

We study the free boundary problem for 2D and 3D incompressible flow in porous media, known as the one-phase Muskat problem. In the absence of surface tension, we prove that when the initial interface is given by a Lipschitz graph, there exists a unique global Lipschitz strong solution. When surface tension is included, we establish small-data global well-posedness and time-decay results in both the whole-space and periodic settings. This talk is based on joint work with Francisco Gancedo (Universidad de Sevilla), Huy Q. Nguyen (University of Maryland), and Hyunwoo (Will) Kwon (Brown University).

Strichartz estimates and well-posedness for a Schrödinger equation with a nonlinear Neumann condition

Schedule: July 7 8:00-8:30 Room 316

Nicola Garofalo

Arizona State University, USA

Co-Author(s): Gigliola Staffilani

Abstract:

I present the well-posedness in a Cauchy problem for a Schrödinger equation with a nonlinear Neumann condition. This represents the appropriate Caffarelli-Silvestre extension problem for a nonlocal nonlinear Schrödinger equation with memory.

Boundary regularity and a priori estimates for fractional equations on unbounded domains

Schedule: July 8 15:00-15:30 Room 316

Yahong Guo

Shanghai Jiao Tong University, Peoples Rep of China

Co-Author(s): Congming Li, Yugao Ouyang

Abstract:

In this talk, we first give a local version of boundary Hölder regularity for nonnegative solutions to the fractional Dirichlet problem in unbounded domains with $C^{1,1}$ boundary. Then as an important application, we establish a priori estimates for solutions to a family of nonlinear fractional equations on unbounded domains with boundaries.

CLASSIFICATION OF SOLUTIONS TO A SINGULAR LANE-EMDEN-FOWLER EQUATION IN THE HALF SPACE

Schedule: July 7 18:00-18:30 Room 316

Yahong Guo

Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

We focus on the classification of positive solutions to $(-\Delta)^s u = \frac{1}{u^\gamma}$ in the half space with $\gamma > 0$, subject to the Dirichlet condition. We show that when $\gamma > 1$, all positive solutions exhibit one-dimensional symmetry and are monotone increasing in x_n . Moreover, we provide a complete classification of all such one-dimensional solutions via their asymptotic s -order slope.

The exterior Bernoulli problem for the half Laplacian

Schedule: July 7 14:00-14:30 Room 316

Sven Jarohs

Goethe University Frankfurt, Germany

Co-Author(s): Tadeusz Kulczycki and Paolo Salani

Abstract:

Given a smooth bounded domain K in $\mathbb{R}^N$ and a parameter $\lambda > 0$, the exterior Bernoulli problem (EBP) for the half Laplacian is to find a function $u : \mathbb{R}^N \rightarrow \mathbb{R}$ and a smooth open subset Ω of $\mathbb{R}^N$ such that $\overline{K} \subset \Omega$ and u is a solution to the problem

$$(-\Delta)^{1/2} u = 0 \quad \text{in } \Omega \setminus \overline{K}, \quad u = 0 \quad \text{in } \mathbb{R}^N \setminus \Omega, \quad u = 1 \quad \text{in } \overline{K},$$

with

$$D_{\Omega}^{1/2} u(\theta) = \lim_{t \rightarrow 0^+} \frac{u(\theta + t\nu(\theta))}{t^{1/2}} = \lambda \quad \text{for all } \theta \in \partial\Omega,$$

where $\nu(\theta)$ denotes the interior unit normal at $\theta \in \partial\Omega$. In this talk, the existence of a solution to the EBP with its geometric properties and resulting regularity is discussed. Furthermore qualitative properties related to the asymptotic behavior of the free boundary of solutions when the Bernoulli's gradient parameter λ tends to 0^+ or to $+\infty$ are presented. The talk is based on two joint works with Tadeusz Kulczycki and Paolo Salani.

Some recent work on qualitative analysis of nonlocal PDEs

Schedule: July 7 13:30-14:00 Room 316

Congming Li

Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

We present some recent work on the analysis of nonlocal problems, focusing on maximum principles, Liouville type theorems, and the classification of solutions. Related results on a priori estimates and regularity are also discussed. Key topics include Hardy-Littlewood-Sobolev type systems and curvature-driven geometric equations.

Global existence and zero relaxation limit for a hyperbolic system arising in traffic flow with large data

Schedule: July 8 9:00-9:30 Room 316

Tong Li

University of Iowa, USA

Co-Author(s): Jose David Beltran

Abstract:

This talk is concerned with the existence of global weak solutions and their zero relaxation limit for a non-strictly hyperbolic system arising in traffic flow with large initial data. We use the vanishing viscosity method and the compensated compactness framework to prove the existence of admissible weak solutions and to study their behavior as the relaxation parameter tends to zero. By constructing convex dissipative entropies that display special compatibility conditions with the local equilibrium equation of the system, we establish the existence and uniqueness of the zero relaxation limit solution for large initial data.

Uniqueness of entire solutions to quasilinear equations with a sub-natural growth term and measure data

Schedule: July 7 17:00-17:30 Room 316

Phuc C Nguyen

Louisiana State University, USA

Co-Author(s): Igor E. Verbitsky

Abstract:

We present the uniqueness of nontrivial solutions to the problem $\left\{ \begin{array}{l} -\Delta_p u = \sigma u^q + \mu, \quad u \geq 0 \quad \text{in } \mathbb{R}^n, \\ \liminf_{|x| \rightarrow \infty} u = 0, \end{array} \right.$ in the sub-natural growth case $0 < q < p - 1$, where μ, σ are nonnegative locally finite measures in $\mathbb{R}^n$ absolutely continuous with respect to the p -capacity. Here $\Delta_p u := \operatorname{div}(|\nabla u|^{p-2} \nabla u)$, $1 < p < \infty$, is the p -Laplace operator. The uniqueness is obtained in the class of *reachable* solutions, and moreover, if the condition $\liminf_{|x| \rightarrow \infty} u = 0$ is replaced by the stronger condition $\lim_{|x| \rightarrow \infty} u = 0$, then such uniqueness is obtained in the larger class of p -superharmonic solutions. This talk is based on joint work with Igor E. Verbitsky.

Uniform Calderón-Zygmund estimates in multiscale elliptic homogenization

Schedule: July 8 13:30-14:00 Room 316

Weisheng Niu

Anhui University, Peoples Rep of China

Co-Author(s): Jinping Zhuge

Abstract:

We report some recent results on the uniform Calderon-Zygmund estimate in the homogenization of elliptic equations with multiscales. Our result includes the uniform Calderon-Zygmund estimate in quasiperiodic elliptic homogenization (even without the Diophantine condition), which was previously unknown. The proof combines the Dirichlet's theorem on the simultaneous Diophantine approximation from number theory, a technique of reperiodization, reiterated periodic homogenization and a large-scale real-variable argument. This a joint work with Jinping Zhuge.

On Hopf's Lemma for sign-changing supersolutions to fractional Laplacian equations

Schedule: July 7 15:00-15:30 Room 316

Enea Parini

Aix Marseille Universite, France

Co-Author(s): Azahara DelaTorre

Abstract:

Unlike in the local case, Hopf's Lemma does not hold true, in general, for sign-changing supersolutions to equations driven by the fractional Laplacian, as proven in a recent paper by Dipierro, Soave and Valdinoci. We investigate the validity of Hopf's Lemma for a (possibly sign-changing) function $u \in H_0^s(\Omega)$ satisfying

$$(-\Delta)^s u(x) \geq c(x)u(x) \quad \text{in } \Omega,$$

where $\Omega \subset \mathbb{R}^N$ is an open set, $c \in L^\infty(\Omega)$ and $(-\Delta)^s u$ is the fractional Laplacian of u . We show that, under suitable assumptions, the validity of Hopf's Lemma for u at a point $x_0 \in \partial\Omega$ is essentially equivalent to the validity of Hopf's Lemma for the Caffarelli-Silvestre extension of u at the point $(x_0, 0) \in \mathbb{R}^N \times \mathbb{R}^+$. The results have been obtained in collaboration with Azahara DelaTorre.

Existence and local uniqueness of solutions to fractional equations with application to fluid dynamics

Schedule: July 7 16:30-17:00 Room 316

Guolin Qin

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Daomin Cao, Shanfa Lai, Weicheng Zhan, Changjun Zou

Abstract:

This talk is concerned with the study of fractional elliptic equations arising from fluid dynamics. Taking the generalized surface quasi-geostrophic (gSQG) equation as a prototype, we investigate the existence, asymptotic behavior, local uniqueness, and nonlinear orbital stability of traveling-wave solutions with small propagation speeds.

Asymptotic behavior for anisotropic fractional energies

Schedule: July 7 14:30-15:00 Room 316

Ariel Salort

CEU San Pablo, Madrid, Spain

Co-Author(s): Julian Fernandez Bonder

Abstract:

We investigate the asymptotic behavior of anisotropic fractional energies as the fractional parameter $s \in (0, 1)$ approaches the critical limits $s \uparrow 1$ and $s \downarrow 0$, in the spirit of the seminal works by Bourgain-Brezis-Mironescu and Maz`ya-Shaposhnikova. Focusing on the limit $s \uparrow 1$, we analyze the stability and convergence of solutions to the corresponding minimization problems. Finally, we examine the interplay between homogenization effects and the localization phenomena that arise as the operator recovers its local structure in the limit $s \uparrow 1$.

Volume growth and Liouville theorems

Schedule: July 7 9:00-9:30 Room 316

Yuhua Sun

Nankai University, Peoples Rep of China

Abstract:

Though volume is a very simple geometric quantity, but it plays a very important role when one studies the geometric and probabilistic properties. We will present how to use volume growth to obtain Liouville type results for elliptic and parabolic equations on manifolds and weighted graphs.

Sobolev and Hardy-Sobolev inequalities and supercritical problems

Schedule: July 7 17:30-18:00 Room 316

John Villavert

University of Texas-Rio Grande Valley, USA

Abstract:

In this talk, we shall describe some supercritical variants of first and second-order Sobolev and Hardy--Sobolev-type embeddings and related elliptic problems that incorporate power nonlinearities with strongly supercritical variable exponents. In particular, we shall describe a variational approach to derive such inequalities. Then, we will discuss how to obtain some existence results for the Dirichlet problem to a class of supercritical elliptic problems with variable exponents in the unit ball, which contrasts with non-existence results for the classical constant exponent case. We will also discuss complimentary non-existence results in both ball domains and the whole space.

Geometric Approach to DeGorgi Nash regularity theorem

Schedule: July 8 8:00-8:30 Room 316

Lihe Wang

University of Iowa, USA

Co-Author(s): Lihe Wang

Abstract:

We will present a new and more geometric transparent approach to the local boundedness theorem of DeGiorgi and Nash.

Regularity of Elliptic Double Phase Problems with Measure Data: Exploring the Exponent Ranges

Schedule: July 8 14:00-14:30 Room 316

Yeonghun Youn

Incheon National University, Korea

Co-Author(s): Kyeong Song

Abstract:

This talk addresses the regularity theory for elliptic double phase problems with measure data. We begin by providing a brief overview of the historical development of existence and regularity results for elliptic problems with measure data. The main focus of this presentation will then shift to the precise conditions on the range of exponents that are crucial for establishing regularity in double phase problems with measure data. We will heuristically demonstrate the optimality of this exponent range through a scaling argument. This work represents a significant step towards understanding the regularity of solutions to this class of challenging problems, and is a joint work with Dr. Song at KIAS.

Optimal convergence rates and uniform regularity for multiscale elliptic homogenization

Schedule: July 8 9:30-10:00 Room 316

Jinping Zhuge

Morningside Center of Mathematics, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Zhongwei Shen, Yao Xu, Weisheng Niu

Abstract:

I will talk about recent progress in homogenization theory for the linear elliptic equations with coefficients periodically oscillating at multiple different microscopic scales. The optimal convergence rates and uniform regularity in various settings will be discussed.

Special Session 16 : The recent progress on qualitative theory of dynamical systems

Organizer(s): Yulin Zhao , Hebai Chen

Introduction: More and more researchers are interested in qualitative theory of dynamical systems and their study has made huge progress in the past decades. This session primarily focuses on the recent progress on qualitative theory of dynamical systems. These advancements encompass aspects like investigating the limit cycle, bifurcation, and normal form, invariant measure in dynamical system, and so on.

Smooth conjugacy of center manifold dynamics

Schedule: July 6 17:00-17:30 Room 822

Shuang Chen

Central China Normal University, Peoples Rep of China

Abstract:

Center manifolds are important invariant sets for dynamical systems which reduces high-dimensional systems to simpler ones on the center manifolds. This makes it possible to analyze bifurcations and stability that would otherwise be intractable. But their non-uniqueness poses a critical obstacle. In this talk, I will present our recent result on smooth conjugacy of center manifold dynamics, i.e., proving that the reduced dynamics are uniquely determined up to smooth equivalence, and then apply the developed theory to resolve some problems in the literature.

Global Dynamics of the Rosenzweig-MacArthur System with Allee Effect

Schedule: July 6 14:00-14:30 Room 822

Zhaosheng Feng

University of Texas Rio Grande Valley, USA

Abstract:

In this talk, we investigate the global dynamics of a Rosenzweig-MacArthur system incorporating an Allee effect in the prey population. Our analysis is carried out within the first quadrant of the Poincare disc, which provides a compactification of the phase space and enables a complete characterization of the system behavior at infinity. The Allee effect introduces a critical threshold below which the prey population cannot persist, thereby fundamentally altering the system bifurcation structure and long-term dynamics. We rigorously characterize equilibria, limit cycles, and their stability, and complement the theoretical results with numerical simulations that illustrate biologically relevant scenarios. Implications for ecological resilience and species extinction thresholds are also discussed.

Stability of some monodromic singularities with two edges in the Newton diagram

Schedule: July 6 13:30-14:00 Room 822

Jaume Gine

Universitat de Lleida, Spain

Co-Author(s): Isaac A. Garcia, Victor Manosa

Abstract:

This work focuses on the study of monodromic singularities in planar analytic families of vector fields whose Newton diagram consists of exactly two edges. We begin by analyzing the desingularization scheme of a minimal model of polynomial vector fields, denoted by $\mathcal{X}$, which includes only the monomials corresponding to the vertices of the Newton diagram. We then extend this minimal model to the so-called Brunella-Miari vector fields $\mathcal{X} \subset \mathcal{X}^{[1]}$, incorporating all monomials associated with points lying on the edges of the Newton diagram. As a second extension, we consider vector fields $\mathcal{X}^{[1]} \subset \mathcal{X}^{[2]}$ that include higher-order terms corresponding to points located above the polygonal line in the Newton diagram. The key point of our approach is to preserve the desingularization geometry at each extension step. We provide explicit desingularization procedures, which enables the computation of the linear part of the return map Π in cases where the desingularized singularity is associated with a hyperbolic polycycle.

Bifurcation and Chaotic Dynamics in Predator-Prey Ecological Models

Schedule: July 6 17:30-18:00 Room 822

Kunlun Huang

Beihang University, Peoples Rep of China

Co-Author(s): Kunlun Huang, Xintian Jia, Yanqi Zhang, Ya li, Cuiping Li

Abstract:

We study a discrete-time predator-prey system with strong Allee effect derived by the Euler discretization. Stability analysis shows that exceeding a critical predator mortality rate generates two interior equilibria and enables species coexistence. The system undergoes fold, flip, and Neimark-Sacker bifurcations with parameter variations. The strong Allee effect stabilizes the system, while weak Allee effect, high predator growth rate, and intensified environmental protection tend to induce periodic orbits and chaotic attractors, verified by Lyapunov exponents and numerical simulations.

Positive Solutions for a Class of Integral Boundary Value Problem of Fractional q-Difference Equations

Schedule: July 6 15:00-15:30 Room 822

Shugui Kang

Shanxi Datong University, Peoples Rep of China

Co-Author(s): Yunfang Zhang, Huiqin Chen and Wenying Feng

Abstract:

In this talk, we studies a class of integral boundary value problem of fractional q-difference equations. We first give an explicit expression for the associated Green's function and obtain an important property of the function. The new property allows us to prove sufficient conditions for the existence of positive solutions based on the associated parameter. The results are derived from the application of a fixed point theorem on order intervals.

The number of zeros of Abelian integrals from Nilpotent Codimension 3 birfucation (Saddle and Elliptic cases)

Schedule: July 6 16:30-17:00 Room 822

Changjian Liu

Sun Yat-sen university, Peoples Rep of China

Abstract:

Dumortier, Roussarie and Sotomayor gave a complete investigation of the unfolding of Bogdanov-Takens bifurcations of codimension 3 based on the hypothesis that there are at most two limit cycles. From then on, this hypothesis becomes a longstanding open problem. According to Dumortier, there are three unsolved classes: elliptic, saddle, focus. For all these three cases, the problem are changed to estimate the number of zeros of some Abelian integrals. By giving new criteria, we prove that the associated Abelian integrals have at most two zeros for elliptic case and saddle case, that is, we give an affirmative answer of this hypothesis for these two cases.

Derivatives of the separation function of generalized saddle connections

Schedule: July 6 14:30-15:00 Room 822

Jordi Villadelprat

Universitat Autònoma de Barcelona, Spain

Co-Author(s): David Marin

Abstract:

A classical formula shows that the breaking of a connection between two hyperbolic saddles s_0^+ and s_0^- can be studied by means of a convergent improper integral that is often called the Melnikov integral. In this talk we will show that this formula extends to more general situations, for instance, when the singularities $s_0^\pm$ are semi-hyperbolic or even nilpotent. In some of these cases the improper integral is no longer convergent but nevertheless, under convenient hypothesis, there is a kind of residue that provides the desired information. Our main result expands the scope of situations in which we can study the breaking of homoclinic or heteroclinic connections. We show that this is indeed the case by analysing three different examples: a heteroclinic connection between nodes, a heteroclinic connection between semi-hyperbolic saddles at infinity and a homoclinic connection in a singularity at infinity. As an application we obtain a general result aimed at studying the breaking of hemicycles and we present several results to analyse the perturbation of unbounded polycycles within a quadratic unfolding that is versal.

Progress in Differentiable Linearization of Dynamical Systems

Schedule: July 6 15:30-16:00 Room 822

Wenmeng Zhang

Chongqing Normal University, Peoples Rep of China

Co-Author(s): Weinian Zhang, Kening Lu, Davor Dragicevic, Yonghui Xia, Weijie Lu

Abstract:

This talk systematically reviews recent advances in differentiable linearization of dynamical systems, a refinement of the classical Hartman-Grobman Theorem. While the theorem guarantees topological conjugacy between a smooth diffeomorphism and its linear part at a hyperbolic fixed point, this conjugacy is generically non-smooth, motivating the core question of its differentiability at the fixed point. We are also concerned with the differentiable normal linearization for partially hyperbolic systems, achieving C^0 conjugacy that is C^1 on the center manifold.

Hyperbolicity of Algebraic Limit Cycles via Abelian Integrals

Schedule: July 6 18:00-18:30 Room 822

Yulin Zhao

Sun Yat-sen University, Peoples Rep of China

Abstract:

This talk establishes a rigorous connection between the hyperbolicity of algebraic limit cycles and Abelian integrals for planar polynomial differential systems admitting invariant algebraic curves. Our results are non-perturbative, i.e., independent of any small parameter, and thus extend the classical Abelian-integral criterion beyond the perturbative framework. We prove that the vanishing of the associated Abelian integral $I(h)$ is a necessary condition for a periodic orbit to lie on an irreducible invariant algebraic curve. Moreover, for a class of systems under suitable constraints, we show that an algebraic limit cycle is hyperbolic if and only if $I'(h) \neq 0$. As an application, we study Kukles systems of arbitrary degree and obtain existence results for algebraic (reversible) limit cycles. By analyzing the zeros of the relevant Abelian integrals, we further demonstrate the coexistence of the algebraic cycle with additional limit cycles, revealing rich global dynamics for this family.

Special Session 17 : Analysis of chemotaxis models

Organizer(s): Johannes Lankeit , Masaaki Mizukami , Mario Fuest

Introduction: The Keller-Segel system and its relatives (both signal-production and signal-consumption variants) play an important role in different contexts in mathematical biology. At the same time, they offer challenging analytical questions, mainly due to lying on the border between global existence and blow-up of solutions, and over the last years have continued to bring forth an extensive mathematical literature. This session intends to showcase recent developments and advancements in the analysis of classical chemotaxis models, regarding occurrence or absence of singularity formation and further solution properties as well as studies of increasingly complex chemotaxis systems. It is expected to bring together researchers interested in various aspects of these systems and to stimulate discussion, facilitate the emergence of new ideas, and inspire new research.

Can Navier-Stokes fluid flows induce blow-up in the logarithmic Keller-Segel system?

Schedule: July 8 15:30-16:00 Room 426

Jaewook Ahn

Dongguk University, Korea

Co-Author(s): Sukjung Hwang

Abstract:

This presentation investigates a two-dimensional Keller--Segel--Navier--Stokes system with a tensor-valued sensitivity $S(x, n, c)$. Under a signal-dependent power-decay condition $|S(x, n, c)| \leq s_0(s_1 + c)^{-\gamma}$, we establish the global boundedness of classical solutions for both fluid-coupled ($\gamma > 1/2$) and fluid-free ($\gamma > 0$) systems. In both cases, the result covers the logarithmic Keller-Segel system ($\gamma = 1$). To overcome mathematical difficulties arising from signal production and fluid transport, our approach utilizes a sequence of localized energy estimates. Furthermore, under specific structural assumptions on the sensitivity tensor, we prove that solutions of the fluid-free system converge exponentially to the spatially homogeneous steady state.

On the blow-up profile and sharp threshold of Keller-Segel-Patlak system

Schedule: July 8 8:30-9:00 Room 426

Xueli Bai

Northwestern Polytechnical University, Peoples Rep of China

Co-Author(s): Hai-Yang Jin, Jingyu Li, Maolin Zhou

Abstract:

In this talk, we consider the Keller-Segel-Patlak system in the whole space with dimensions $N \geq 3$. In the first part, we solve an open problem proposed by Souplet and Winkler in [CMP,2019]. To establish this result, we develop the zero number argument for nonlinear equations with unbounded coefficients and construct a family of auxiliary backward self-similar solutions through nontrivial ODE analysis. Examining the behavior of a parameter-dependent solution in the second part, we show the existence of a sharp threshold between extinction (i.e., convergence to 0) and blowup (i.e., convergence to ∞). This is a joint work with Hai-Yang Jin, Jingyu Li and Maolin Zhou.

Global solvability for a stochastic hyperbolic Keller - Segel system

Schedule: July 7 17:30-18:00 Room 426

Nikolai V Chemetov

University of Sao Paulo, Brazil

Co-Author(s): L.K. Arruda

Abstract:

In this work we study the stochastic Stratonovich hyperbolic Keller-Segel model with an infinite dimensional multiplicative noise in a bounded domain. We establish the global-in-time existence result for weak entropy martingale solutions to this stochastic Keller-Segel model. The proof combines the stochastic a priori estimates with compactness techniques based on the kinetic theory and on the Jakubowski-Skorokhod representation theorem. The dependence of the noise function makes more difficult for the analysis of a priori estimates, giving rise to nonlinear terms induced by the martingale part of the equation and the Stratonovich correction term.

Threshold dynamics in the nonlinear stability exchange of constant steady states for Keller-Segel systems

Schedule: July 8 15:00-15:30 Room 426

Mengyao Ding

Harbin institute of Technology, Peoples Rep of China

Abstract:

Abstract: In this paper, we investigate constant steady states of the system
$$\begin{cases} u_t = \Delta u - \chi \nabla u \cdot \nabla (u \nabla v) \\ v_t = \Delta v - a v + b u, \end{cases} \quad \text{in } \Omega, \quad \text{subject to homogeneous Neumann boundary conditions, where } \Omega \subset \mathbb{R}^N \text{ is a bounded domain and } a, b, \chi > 0. \text{ The main contribution is identifying a critical threshold for constant steady states that governs the exchange of stability, as reflected in the dynamics of the solutions. Due to the lack of quantitative information on the threshold in the existing theory, this work provides a universal constant } \sigma_0 > 0 \text{ with an explicit value to determine the stability behavior of solutions. Whenever } \sigma > \sigma_0, \text{ we show that } (\sigma, \frac{b\sigma}{a}) \text{ is Lyapunov unstable. Previous results on Lyapunov instability were limited to the two- or three-dimensional torus. We overcome this limitation in our instability analysis by introducing a new method based on a special paring of different frequencies. We emphasize that this method can lead to an establishment of Lyapunov instability whenever the linearized operator associated with (KS) possesses a positive eigenvalue. Thus, it enables us to consider general domains in arbitrary dimensions } N \geq 2, \text{ and is also adaptable to studying unstable behaviors for a wide class of related problems.}$$

Behavior of Dirac Singularities in the Parabolic-Elliptic Keller-Segel System in Dimensions

$n \geq 3$

Schedule: July 8 14:00-14:30 Room 426

Gregor M Fluechter

Paderborn University, Germany

Abstract:

We study radially symmetric solutions to the parabolic-elliptic Keller-Segel system of the form
$$\begin{cases} u_t = \Delta u - \nabla u \cdot \nabla (u \nabla v) \\ v_t = \Delta v - \mu v + u, \end{cases} \quad \text{in } \Omega, \quad \text{with } u_0 \in C^0(\overline{\Omega}), \text{ subjected to homogeneous Neumann boundary conditions and posed in the domain } \Omega = B_R(0) \subset \mathbb{R}^n \text{ for some } R > 0 \text{ and } n \geq 3. \text{ In two dimensions, it is well-known that solutions blowing up in finite time converge to a Dirac profile in the vague topology. In dimensions greater or equal to three, there are cases in which Dirac singularities do form, although at least for radially decreasing initial data only some time after blow-up. Examining the system } \begin{cases} u_t = \Delta u - \nabla u \cdot \nabla (u \nabla v) \\ v_t = \Delta v - \mu v + u, \end{cases} \quad \text{in } (0, R^n), \quad \text{with } u(R^n, t) = \frac{\mu R^n}{n}, \quad \text{for } t > 0, \text{ emerging from a transformation of } (\star), \text{ specifically } w(s, t) = \int_0^{\frac{s}{n}} \rho^{n-1} u(\rho, t) d\rho, \text{ we may trace the evolution of solutions further than the blow-up time of } (\star) \text{ and thus analyze the behavior of the Dirac singularity corresponding to } w(0, t) > 0. \text{ In particular, we shall focus on the monotonicity and long-term behavior of } t \mapsto w(0, t).$$

Absence of critical mass phenomena in one-dimensional critical quasilinear Keller-Segel systems

Schedule: July 7 16:30-17:00 Room 426

Mario Fuest

University of Kassel, Germany

Co-Author(s): Xinru Cao

Abstract:

In the higher dimensional setting, critical mass phenomena are known to occur in the quasilinear Keller--Segel system for a variety of different diffusion rates $D(u)$ and taxis sensitivity functions $S(u)$ being critical in the sense that $\frac{S(u)}{D(u)} \sim u^{\frac{n}{2}}$ for large u , where n denotes the space dimension. The most famous example is the two-dimensional minimal Keller--Segel system given by $D(u) = 1$ and $S(u) = u$, for which the mass 4π (or 8π in the radially symmetric case) distinguishes between boundedness and the possibility of blow-up. In this talk, based on a recent joint work with Xinru Cao, it is shown that this is no longer the case for one-dimensional domains: Solutions of the quasilinear system with $D(u) = (u + 1)^{m-1}$ and $S(u) = u(u + 1)^m$ for (many) $m \in \mathbb{R}$ emanating from initial data with arbitrary large mass are globally bounded. Accordingly, the absence of a critical mass phenomenon appears to be a general property of the one-dimensional setting and is not limited to the case $m = 0$ already studied in the literature.

On a Thermodynamically Consistent Diffuse-Interface Model for Incompressible Two-Phase Flows with Chemotaxis and Mass Transport

Schedule: July 7 17:00-17:30 Room 426

Andrea Giorgini

Politecnico di Milano, Italy

Co-Author(s): Jingning He, Hao Wu

Abstract:

We investigate a hydrodynamic system of Navier--Stokes/Cahn--Hilliard type, which describes the motion of a two-phase flow of two incompressible fluids with unmatched densities coupled with a soluble chemical species. Derived from Onsager's variational principle, this thermodynamically consistent diffuse-interface model incorporates both the chemotaxis effects induced by the chemical species and the mass transport processes within the mixture. For the two-dimensional initial-boundary value problem, we establish the existence of global finite energy solutions and global weak solutions, using a suitable approximation scheme combined with compactness methods. Next, by carefully analyzing three decoupled subsystems and employing a bootstrap argument, we prove the existence and uniqueness of a global strong solution for sufficiently regular initial data, as well as the propagation of regularity for global weak solutions. In particular, we show that the density of the chemical substance stays bounded for all time if its initial datum is bounded. This implies a significant distinction from the classical Keller--Segel system: diffusion driven by the chemical potential gradient can prevent the formation of concentration singularities.

Global Existence and Asymptotic Behavior for a Swirl-Free 3D Axisymmetric Chemotaxis-Navier-Stokes System

Schedule: July 8 9:30-10:00 Room 426

Dongkwang Kim

Ulsan National Institute of Science and Technology (UNIST), Korea

Co-Author(s): Kyungkeun Kang, Jaewook Ahn

Abstract:

This talk concerns a three-dimensional chemotaxis-Navier-Stokes system modeling the directed motion of cells toward a consumable chemical substrate. Assuming axisymmetric initial data without swirl, we establish the global existence of unique classical solutions for general tensor-valued sensitivities. The proof relies on coupled a priori estimates to resolve the chemotactic interaction, exploiting the geometric properties of the axisymmetric no-swirl flow. Furthermore, we determine the asymptotic behavior of the global solutions, proving their stabilization to the trivial equilibrium at polynomial decay rates coinciding with those of the linear heat equation.

Recent progress on stability of stationary solutions to a chemotaxis system with flux-dependent sensitivity

Schedule: July 8 13:30-14:00 Room 426

Shohei Kohatsu

Tokyo University of Science, Japan

Co-Author(s): Takasi Senba

Abstract:

We will consider a chemotaxis system with flux-dependent sensitivity, and discuss some properties of solutions. In particular, we present results on layer structure and stability of stationary solutions.

On positive steady states of an epidemic PDE model with singular chemotaxis sensitivity

Schedule: July 8 17:30-18:00 Room 426

Rachidi B Salako

University of Nevada Las Vegas, USA

Co-Author(s): Y. Lou, Y. Tao, S. Zhou

Abstract:

We study the structure of positive steady states in a cross-diffusive susceptible-infected-susceptible (SIS) epidemic reaction-diffusion model, in which susceptible individuals tend to avoid regions with relatively high densities of infected individuals. Standard bifurcation methods are not applicable in this setting, as there is no evident disease-free equilibrium from which positive solutions can bifurcate. In addition, defining the basic reproduction number becomes significantly more difficult due to the presence of singular chemotaxis sensitivity in the model. To address these issues, we develop a new analytical framework. Using this approach, we establish results on the existence, uniqueness, and multiplicity of positive steady states. Furthermore, we characterize the asymptotic profiles of these steady states in the regime of large chemotaxis sensitivity coefficients.

Existence and uniqueness of global weak solutions to degenerate chemotaxis systems with prevention of overcrowding

Schedule: July 7 18:00-18:30 Room 426

Osuke Shibata

Tokyo University of Science, Japan

Co-Author(s): Tomomi Yokota

Abstract:

We consider a no-flux initial-boundary value problem for the degenerate volume-filling chemotaxis system with diffusion and chemotactic sensitivity depending on cell densities and signal concentration. We first prove that there exists a global weak solution. Second, under some additional conditions, we show uniqueness of global weak solutions with the mass conservation law. Moreover, we construct a flat-hump-shaped stationary solution in the one-dimensional setting. These results extend the ones in Laurencot-Wrzosek (2005), where they studied a related problem with diffusion and chemotactic sensitivity depending only on cell densities.

Blow-up in a chemotaxis system with p -Laplacian diffusion

Schedule: July 8 17:00-17:30 Room 426

Yuya Tanaka

Department of Mathematical Sciences, Kwansei Gakuin University, Japan

Co-Author(s): Monica Marras

Abstract:

This talk deals with a parabolic--elliptic chemotaxis system with p -Laplacian diffusion. In previous related works, global existence and boundedness of solutions were established for the case $p > 3N/(N+1)$. In this talk, we discuss finite-time blow-up of solutions in the opposite case. This is a joint work with Monica Marras (University of Cagliari).

Cross-diffusion system with doubly degenerate nonlinear diffusion and strong chemotactic effect

Schedule: July 8 16:30-17:00 Room 426

Bao-Ngoc Tran

University of Graz, Austria

Co-Author(s): Juan Yang

Abstract:

Motivated by the study of bacteria's response to environmental conditions, we consider the doubly degenerate nutrient taxis system governed by $u_t = \nabla \cdot (uv \nabla u) - \nabla \cdot (u^\alpha v \nabla v) + uv$ and $v_t = \Delta v - uv$, where $\alpha \in [0, 2]$ is the bacterial response parameter. Global weak solvability is highly challenging due to both the doubly degenerate diffusion and the strong chemotactic effect; we establish this for $0 \leq \alpha < 2$, see <https://arxiv.org/pdf/2508.03268>.

Stability of constant steady states of solutions to a chemotaxis model

Schedule: July 8 14:30-15:00 Room 426

Hiroshi Wakui

University of Fukui, Japan

Abstract:

We consider the Cauchy problem for an attraction-repulsion chemotaxis system in $\mathbb{R}^n$ that admits a continuum of constant steady states. In the attractive case, positive constant steady states are stable under suitable conditions, whereas, in the repulsive case, all positive constant steady states are stable. We establish a sharp stability criterion for constant steady states in the general attraction-repulsion setting. We show that a constant steady state is asymptotically stable under sufficiently small perturbations whenever its amplitude is below an explicit threshold determined by the system parameters. This provides a refined classification of stability based on the balance between attractive and repulsive effects.

A sufficient condition for boundedness in direct (and indirect) chemotaxis-consumption models with signal-dependent sensitivity

Schedule: July 8 9:00-9:30 Room 426

Tomomi Yokota

Tokyo University of Science, Japan

Co-Author(s): Khadijeh Baghaei, Yutaro Chiyo, Chihaya Machino

Abstract:

In this talk we consider a class of direct (and indirect) chemotaxis-consumption systems with signal-dependent sensitivity. In previous studies, boundedness of solutions to the system has been obtained under some restrictions on the dimension and the diffusion coefficient. The purpose of this talk is to remove these restrictions.

Special Session 18 : Progress on delay and fractional differential equations with real-world application

Organizer(s): Kunquan Lan , Elena Braverman

Introduction: This special will bring together researchers working on dynamical systems, delay differential equations, fractional differential equations, and their applications in mathematical biology, physics and engineering, to present and discuss recent developments and future directions in the research areas and encourage interdisciplinary collaborations. Related topics: dynamical systems, delay fractional differential equations and applications to mathematical biology, physics and engineering. The emphasis is given to the discontinuous nonlinearities. An invited speaker will have a 30 minutes` presentation on any topic of your choice related to the special session (25 minutes for a presentation and 5 minutes for questions and discussion).

On delay differential equations and systems with a non-delay or weakly delayed term

Schedule: July 6 14:30-15:00 Room 538

Elena Braverman

University of Calgary, Canada

Co-Author(s): Leonid Berezansky

Abstract:

It is well known that an equation with a dominating non-delay negative term is asymptotically stable, independently of the magnitude of the delay. For non-linear delay models of population dynamics, systems with non-linear mortality are also common and can exhibit global asymptotic stability of a positive equilibrium, under some limitations on the form of the production function. We discuss linear systems with a non-delay term, systems with a dominating term that has a small delay, and non-linear models with delayed mortality.

Coupled Delayed Negative Feedback Loops in Biological Systems: Oscillations and Stability

Schedule: July 6 18:30-19:00 Room 538

Jacques Bélair

Université de Montréal, Canada

Abstract:

Biological regulatory systems are often appropriately modeled as coupled systems of nonlinear delay differential equations. For example, the production of mammalian blood cells involves an intertwined network of physiological processes, with nonlinear, delayed feedback control mechanisms: erythrocytes (red blood cells) and thrombocytes (platelets) while each having their own main regulatory hormone, erythropoietin and thrombopoietin respectively, are also interacting, specially in pathological conditions. We consider the (highly) simplified model

$$\begin{cases} x'(t) = -\alpha x(t) + f(x(t - \tau_1), y(t - \tau_2)) \\ y'(t) = -\beta y(t) + g(x(t - \tau_1), y(t - \tau_2)) \end{cases}$$

with f and g appropriate Hill functions for the coupled regulation of these two cell lines to study how the interaction of the control mechanisms may influence the dynamics. Equilibrium solutions are determined, their stability established and the nature of the oscillations when instability occurs are investigated. The linear analysis revolves around a transcendental characteristic equation of second order with two delays; a Centre manifold analysis at the change of stability of equilibria provides insight into possible dynamics. Possible extensions will also be discussed.

Subordination in sign-constancy of Green's function for fractional differential boundary value problems: from focal to multipoint and non-local problems

Schedule: July 6 15:00-15:30 Room 538

Rajarshi Dey

Ariel University, Israel

Co-Author(s): Rajarshi Dey, Alexander Domoshnitsky, and Seshadev Padhi

Abstract:

This paper establishes sign constancy of Green's function criteria for a class of boundary value problems involving fractional differential equations. We study equations driven by the Riemann--Liouville fractional derivative of order $\beta \in (n - 1, n]$, coupled with linear continuous Volterra operators acting on unknown function and its derivatives. The main development of this paper is the idea of subordination in sign properties of Green's functions for various boundary value problems. Starting with focal problems, we can conclude about sign-constancy of others, for example, multipoint and non-local problems can be among them. For focal problem, we demonstrate equivalence of the fact of sign constancy of Green's function and its derivatives, and the fact that the spectral radius of corresponding compact operator is less than one. Furthermore, a Vall'ee--Poussin--type comparison theorem is established. Several illustrative examples, including equations with integral terms and deviating arguments, are presented to demonstrate the applicability of the obtained assertions. The results extend classical Vall'ee--Poussin theorem to fractional differential equations with functional perturbations.

Lyapunov-type inequalities for fractional boundary value problems and applications

Schedule: July 7 8:30-9:00 Room 538

Sougata Dhar

Fairfield University, USA

Co-Author(s): Jessica Kelly, Qingkai Kong

Abstract:

In this talk, we discuss boundary value problems involving Riemann-Liouville fractional differential equations with certain fractional integral boundary conditions. Such boundary conditions are different from the widely considered point wise conditions in the sense that they allow solutions to have singularity, and different from other conditions given by integrals with a singular kernel since they arise from well defined initial value problems. We derive Lyapunov-type inequalities and apply them to establish several qualitative criteria for the solutions of these problems. We demonstrate the extensions to the multivariate domain. Parallel results are also obtained for sequential fractional differential equations. An example is given to show how computer programs and numerical algorithms can be used to verify the conditions and to apply the results. We will conclude with an open problem.

Floquet theory in stability studies of delay differential equations

Schedule: July 7 13:30-14:00 Room 538

Alexander Domoshnitsky

Ariel University, Israel

Co-Author(s): Alexander Domoshnitsky

Abstract:

In this talk, we propose tests of exponential stability based on a version of the Floquet theory for delay differential equations. Our approach allows researchers to preserve the order of equation and to use the classical methods of the Floquet theory for ordinary differential equations. On this basis, new original unexpected results on the exponential stability are proposed. We demonstrate that choosing period of coefficients and delays of the gain in corresponding intervals allows to achieve the exponential stabilization in the cases considered as impossible when the standard technique was applied.

Series approach to quasi-Bessel, Cauchy-Euler and constant-coefficient fractional ODEs

Schedule: July 6 15:30-16:00 Room 538

Pavel Dubovski

Stevens Institute of Technology, USA

Co-Author(s): J.A.Slepoi

Abstract:

We discuss the methods for constructing solutions in the form of series. These techniques assist in assessing well-posedness and, in some cases, lead to representations involving classical special functions. We highlight multi-series approaches, particularly solutions expressed as double and triple series. We address the fundamental sets of solutions and introduce new existence, uniqueness, and non-uniqueness results for linear fractional differential equations, including constant-coefficient, Cauchy-Euler and quasi-Bessel equations

$$\sum_{i=1}^m d_i x^{\alpha_i + p_i} D^{\alpha_i} u(x) + (x^\beta - \nu^2) u(x) = 0.$$

Analytic findings are supported by computations.

Persistence for differential equations with unbounded delays

Schedule: July 6 14:00-14:30 Room 538

Teresa Faria

University of Lisbon, Portugal

Co-Author(s): Jos\`e J. Oliveira

Abstract:

For a family of non-autonomous multi-dimensional differential equations with unbounded delays, sufficient conditions for their persistence are established. Applications to mathematical biology models with unbounded delays are given. These results generalise and enhance recent criteria for persistence for the case of finite delays. \begin{thebibliography}{99} \bibitem{FO26} T. Faria, J.J. Oliveira, Persistence for a class of nonautonomous systems of differential equations with unbounded delays, Mathematical Bioscience (to appear). doi: 10.1016/j.mbs.2026.109670 \end{thebibliography}

Geometry of Mittag-Leffler type functions and Fractional differential/difference equations

Schedule: July 7 9:00-9:30 Room 538

Rui Ferreira

Universidade do Porto, Portugal

Abstract:

We present our recent results about the geometry of the Mittag-Leffler function (and its generalizations), specially with respect to the parameter. Then, we discuss some applications to fractional differential and difference equations.

Communication Dynamics in Human-Automation Teaming: Discrete-Time versus Delay Differential Equation Approaches

Schedule: July 6 13:30-14:00 Room 538

Yun Kang

Arizona State University, USA

Co-Author(s): Carlos Bustamante-Orellana; Lucero Rodriguez

Abstract:

Effective communication is essential for coordination and cooperation within teams, directly influencing their efficiency and success. To better understand communication dynamics and their impact on team performance, we develop a modeling framework of two-agent interaction dynamics using both a discrete-time approach and a delay differential equation approach. The models capture communication exchanges between agents based on personality traits and the influence of received communication. Supported by data, we apply mathematical analysis and bifurcation diagrams to examine how personality and training shape communication quality and, in turn, task performance. Model validation and parameter estimation offer practical applications, including selecting team members who can collaborate effectively and improving communication training within established teams. By comparing outcomes from the discrete-time and delay-based models, we provide insights into the strengths of each approach and guidance on selecting the most suitable framework for modeling team communication.

Are nonlinear first order Caputo fractional differential equations solvable?

Schedule: July 6 17:00-17:30 Room 538

Kunquan Lan

Toronto Metropolitan University, Canada

Co-Author(s): Kunquan Lan

Abstract:

Consider the first order Caputo fractional differential equation (FDE) $(D_{-}\{C,a^{+}\})^{\alpha}u(x) = f(x, u(x))$ for almost every $x \in [a, b]$, where $\alpha \in (0, 1)$, I_{a+}^{α} is the Riemann-Liouville fractional integral, u' is the traditional first-order derivative and $f : [a, b] \times [0, \infty) \rightarrow \mathbb{R}$ is a function. The Caputo FDE can be a single equation or a system of equations. It was claimed in some previous papers that if f satisfies the locally Lipschitz condition in the second variable, then the Caputo FDE has a unique solution. However, the result would be incorrect, see the open question below. The above result has been widely used in the literature to obtain the existence and uniqueness of solutions of a variety of models such as disease models and predator-prey models published, for example in Scientific Reports, PLoS One, Epidemics, Communications in Nonlinear Science and Numerical Simulation. However, these previous results which applied the above claimed result to obtain the existence and uniqueness of solutions of the models would not be correct unless one can prove that the locally Lipschitz condition implies the necessary condition for the Caputo FDE to have solutions:

$$Fu \in I_{a+}^{\alpha}(L^1[a, b]) \quad \text{for all } u \in S,$$

where S is a ball in $C_+[a, b]$ and $(Fu)(x) = f(x, u(x))$ for almost every $x \in [a, b]$. The open question is under what conditions on the nonlinearity f , does the above necessary condition hold? It is noted that if the nonlinearity f satisfies the locally Lipschitz condition in the second variable or is infinitely differentiable, it is unknown whether f satisfies the necessary condition.

On the Uniqueness of Solutions to a Nonlinear Fractional Pantograph-Type Equation with a Functional Initial Condition

Schedule: July 6 16:30-17:00 Room 538

Chenkuan Li

Brandon University, Canada

Co-Author(s): Chenkuan Li

Abstract:

The objective of this paper is to investigate the uniqueness of solutions for a nonlinear fractional pantograph-type equation with proportional delays and a functional initial condition in the space of absolutely continuous functions. The analysis is carried out using the inverse operator method, the multivariate Mittag-Leffler function, and Banach's fixed-point theorems. An illustrative example is presented to demonstrate the applicability of the main result.

Babenko's method for fractional integral and differential equations and their q-analogues

Schedule: July 6 17:30-18:00 Room 538

Min-Jie Luo

Donghua University, Peoples Rep of China

Abstract:

Very recently, Babenko's method, also known as the inverse operator method, has been revitalized and widely applied to solve various differential and integral equations. In this talk, we will briefly describe this method and show its usefulness in solving certain classes of fractional integral and differential equations and their q-analogues. Some interesting q-analogues of known special functions and operators will also be introduced. This is joint work with Ravinder Krishna Raina, Xue-Lin Zhou and Qing-Hui Peng.

An application of the Leray-Schauder nonlinear alternative to a Riemann-Liouville fractional boundary value problem with Lidstone-inspired fractional conditions

Schedule: July 7 9:30-10:00 Room 538

Jeffrey Lyons

The Citadel, USA

Co-Author(s): Jeffrey T. Neugebauer and Aaron Wingo

Abstract:

This paper demonstrates the existence of solutions for a class of nonlinear Riemann--Liouville fractional boundary value problems of order $\alpha + 2n$ where $\alpha \in (1, 2]$ and $n \in \mathbb{N}$. The conjugate fractional boundary conditions are Lidstone-inspired. The nonlinearity is assumed to be continuous, and we impose suitable growth conditions to establish the existence of solutions. Our approach relies on the construction of a Green's function using the convolution of the Green's functions of lower-order fractional boundary value problems and the Leray--Schauder Nonlinear Alternative Theorem.

Exponential stability of second order delay differential equations through Floquet theory

Schedule: July 7 14:00-14:30 Room 538

Sergey Malev

Ariel University, Israel

Co-Author(s): Alexander Domoshnitsky, Tsahi Shavit.

Abstract:

In this talk, we obtain results on the exponential stability of second order delay differential equations, which are based on a version of the Floquet theory for delay differential equations of the second order we proposed. Our version allows researchers to preserve the order of equation and to obtain analogues of the classical results of the Floquet theory known for ordinary differential equations. On the basis of our version of the Floquet theory, new original unexpected results on the exponential stability are proposed. We demonstrate that choosing period of coefficients and delays of the gain in corresponding intervals allows to achieve the exponential stabilization in the cases considered as impossible when the standard technique was applied.

Inverse Problem for Abstract Degenerate Delay Differential Equation

Schedule: July 7 8:00-8:30 Room 538

Santosh Ruhil

Ariel University, Israel

Abstract:

Inverse problems play an important role in mathematics and its applications, as they aim to determine unknown components of a system from indirect observations. Such problems become particularly challenging when the underlying dynamics involve delays and degeneracy, which frequently appear in models with memory and singular behaviour. In this talk, we consider a first-order identification problem for a class of abstract degenerate delay differential equations in a Banach space. The main objective is to determine unknown elements of the system dynamics using additional observational data. Under suitable assumptions on closed linear operators, the degenerate problem can be reduced to an equivalent nondegenerate formulation, which allows us to establish the unique solvability of the identification problem. The more general situation is then analyzed using recent results concerning convolution techniques, which enable the simultaneous treatment of delay effects and degeneracy. Finally, an example is presented to illustrate the applicability of the abstract results and to demonstrate their validity.

Time delayed models and optimal control in infectious disease dynamics

Schedule: July 7 15:30-16:00 Room 538

Cristiana J. Silva

Iscte - IUL and CIDMA, University of Aveiro, Portugal

Abstract:

Time delays are intrinsic to many infectious disease processes, arising from biological latency, intracellular dynamics, and delays in immune response or transmission. In this talk, we introduce time-delayed mathematical models formulated as systems of delayed differential equations and related optimal control problems, applied to two case studies: HIV in-host dynamics and the population-level transmission of brucellosis. For HIV, we develop both compartmental and in-host models incorporating biologically motivated delays associated with viral replication and immune cell activation. An optimal control problem is formulated to assess combined antiretroviral therapy and immunotherapy. The problem includes state constraints on effector immune cells, and we derive the necessary optimality conditions using Pontryagin's Maximum Principle for delayed systems. Numerical simulations highlight the impact of delays on treatment strategies and the trade-offs between therapeutic effectiveness and treatment side effects. In parallel, we examine a delayed epidemiological model for brucellosis transmission in livestock and humans, featuring multiple latent-period delays. Taken together, these studies illustrate how delayed models and optimal control provide powerful tools for understanding infection mechanisms and for designing effective intervention strategies.

Existence of positive solutions for boundary value problems involving Riemann-Liouville derivatives

Schedule: July 7 15:00-15:30 Room 538

Satoshi Tanaka

Tohoku University, Japan

Co-Author(s): Satoshi Tanaka

Abstract:

We investigate the existence, non-existence, uniqueness, and multiplicity of positive solutions to the following problem $D_{0+}^{\alpha} u + h(t)f(u) = 0$ for $t \in (0, 1)$; $u(0) = u(1) = 0$, where D_{0+}^{α} is the Riemann-Liouville fractional derivative of order $\alpha \in (1, 2]$. Firstly, by characterizing the first eigenvalue $\lambda_1(\alpha)$ of the associated eigenvalue problem, we establish the existence of positive solutions for both sublinear and superlinear cases relative to $\lambda_1(\alpha)$, thereby extending previously known results. Secondly, we address the uniqueness of these solutions. In the sublinear case, we impose certain monotonicity conditions on f , while for the superlinear case, we assume a specific condition on h to ensure uniqueness at $\alpha = 2$. For values of α near 2, uniqueness is established by leveraging the non-degeneracy of the unique solution. Finally, we apply this methodology to H^{∞} -non-type problems to demonstrate the existence of at least three positive solutions. This is a joint work with Inbo Sim (University of Ulsan).

Stabilization Method of n-th Order ODEs Using a Distributed Control Functions Expressed in Integral Form

Schedule: July 7 14:30-15:00 Room 538

Irina Volinsky

Ariel University, Israel

Abstract:

The stabilization of solutions by distributed feedback control functions for second- and third-order ordinary differential equations (ODEs) has been presented in earlier studies. The present work extends these results to the stabilization of n -th order ODEs using a distributed control function expressed in integral form. The problem of stabilization of n -th order ODE solutions by distributed control functions is significantly more complex and nontrivial. This work introduces a method for selecting the parameter set within the distributed control function. Furthermore, the connection between palindromic polynomials, log-concavity, and stability with respect to initial conditions (Lyapunov stability) in n -th order ODEs with distributed feedback control functions is established.

Special Session 19 : Topics on singular stochastic equations

Organizer(s): Xicheng Zhang , Jian Wang , Wei Liu

Introduction: Singular stochastic equations are a class of stochastic differential equations (SDEs) that involve singularities, which can arise in various forms such as singular coefficients, singular noise, or singular initial/boundary conditions. These equations are of significant interest in both theoretical and applied mathematics due to their relevance in modeling complex systems in physics, biology, finance, and engineering, where abrupt changes or extreme behaviors are observed. We plan to invite 12 speakers taking about recent progress about this topic.

Wave propagation for 1-dimensional reaction-diffusion equations with nonzero random drift

Schedule: July 9 16:30-17:00 Room 641

Hui He

Beijing Normal University, Peoples Rep of China

Co-Author(s): Dihang Guan, Wenqing Hu, Jiaojiao Yang

Abstract:

We consider the wave propagation for a reaction-diffusion equation on the real line, with a random drift and Fisher-Kolmogorov-Petrovskii-Piscounov (FKPP) type nonlinear reaction. We show that when the average drift is positive, the asymptotic wave fronts propagating to the positive and negative directions are both pushed in the negative direction, leading to the possibility that both wave fronts propagate toward negative infinity. Our proof is based on the Large Deviations Principle for diffusion processes in random environments, as well as an analysis of the Feynman-Kac formula. Such probabilistic arguments also reveal the underlying physical mechanism of the wave fronts formation: the drift acts as an external field that shifts the (quenched) free-energy reference level without altering the intrinsic fluctuation structure of the system.

Fluctuation of heat kernels on random graphs.

Schedule: July 9 17:00-17:30 Room 641

Lu-Jing Huang

Fujian Normal University, Peoples Rep of China

Abstract:

Let $\mathcal{G}$ be a graph equipped with random conductance. We give sufficient conditions for the Markov chain on $\mathcal{G}$ to exhibit large scale fluctuations in its on-diagonal heat kernel. The conditions also imply non-tightness of the height process w.r.t. the quenched measure, while the height process is tight w.r.t. the annealed measure. As an application of the general theory, we prove large scale fluctuations for the simple random walk on 1-dimensional critical long-range percolation. This is based on a joint work with Zherui Fan and Takashi Kumagai.

Regularization by noise phenomena in stochastic nonlinear PDEs with modulated dispersion

Schedule: July 9 17:30-18:00 Room 641

Guopeng Li

Beijing Institute of Technology, Peoples Rep of China

Abstract:

In this talk, we first consider the Korteweg-de Vries equation (KdV) with a modulated dispersion. We observe the regularization-by-noise effects resulting from this modulation: we establish well-posedness of the modulated KdV on the circle in the regime where the unmodulated KdV is ill-posed. In particular, we show that the modulated KdV on the circle is locally well-posed in Sobolev spaces of arbitrarily low regularity, provided that the modulation is sufficiently irregular. Then I will present more recent results on the stochastic modulated KdV on the circle with multiplicative fractional-in-time noise, where we establish a new regularization-by-noise phenomenon on the stochastic convolution in a pathwise manner, where a gain of spatial regularity becomes (arbitrarily) larger for more irregular modulations. We then prove that the stochastic modulated KdV is pathwise locally well-posed in Sobolev spaces of arbitrarily low regularity, provided that the modulation is sufficiently irregular. If time permits, I will mention the results when the multiplicative noise is white-in-time. Based on joint works with Khalil Chouk (formerly Edinburgh), Massimiliano Gubinelli (Oxford), Jiawei Li & Tadahiro Oh (Edinburgh), and Andreia Chapouto (CNRS & Monash).

Transportation-cost information inequalities for McKean-Vlasov equations and mean field interacting particle system

Schedule: July 10 8:00-8:30 Room 641

Wei Liu

Wuhan University, Peoples Rep of China

Co-Author(s): Liming Wu

Abstract:

TDA

Schrodinger-Follmer Sampler

Schedule: July 9 18:00-18:30 Room 641

Yanyan Liu

Wuhan University, Peoples Rep of China

Co-Author(s): Jian Huang , Yuling Jiao, Lican Kang , Xu Liao, Jin Liu, Yanyan Liu

Abstract:

Sampling from probability distributions is an important problem in statistics and machine learning, specially in Bayesian inference when integration with respect to posterior distribution is intractable and sampling from the posterior is the only viable option for inference. In this paper, we propose Schrodinger-Follmer sampler (SFS), a novel approach to sampling from possibly unnormalized distributions. The proposed SFS is based on the Schrodinger-Follmer diffusion process on the unit interval with a time-dependent drift term, which transports the degenerate distribution at time zero to the target distribution at time one. Compared with the existing Markov chain Monte Carlo samplers that require ergodicity, SFS does not need to have the property of ergodicity. Computationally, SFS can be easily implemented using the Euler-Maruyama discretization. In theoretical analysis, we establish nonasymptotic error bounds for the sampling distribution of SFS in the Wasserstein distance under reasonable conditions. We conduct numerical experiments to evaluate the performance of SFS and demonstrate that it is able to generate samples with better quality than several existing methods.

Quantitative Asymptotics for Time-Inhomogeneous Lévy-Driven SDEs with Asymptotically Vanishing Drifts

Schedule: July 10 8:30-9:00 Room 641

Jian Wang

Fujian Normal University, Peoples Rep of China

Abstract:

We are concerned with a class of multi-dimensional time-inhomogeneous stochastic differential equations (SDEs) on $\mathbb{R}^d$ driven by pure-jump Lévy processes, where the drift coefficient $b(t, x)$ satisfies $\lim_{t \rightarrow \infty} b(t, x) = 0$ for every $x \in \mathbb{R}^d$. Distinguishing three regimes according to the index α of large jumps for the driven Lévy noise, we investigate the quantitative asymptotic behavior of the corresponding rescaled processes. More precisely, for $\alpha \in (0, 2)$, we prove that the rescaled processes, governed by time-inhomogeneous SDEs driven by additive processes, converge with respect to suitably chosen Wasserstein distances to time-homogeneous SDEs driven by symmetric α -stable processes. Notably, the driving noise in the limiting SDEs depends only on large jumps of the underlying additive processes. A phase transition occurs for all values of the index α , and a diffusive phenomenon arises whenever $\alpha \geq 2$.

On reflected SDEs with superlinear coefficients

Schedule: July 10 9:00-9:30 Room 641

Jing Wu

Sun Yat-sen University, Peoples Rep of China

Abstract:

In this talk we are concerned with some problems of reflected SDEs when both the drift and diffusion coefficients are of superlinear growth, including the well-posedness and numerical approximations.

Stochastic Differential Equations with Local Growth Singular Drifts

Schedule: July 10 9:30-10:00 Room 641

Wenjie Ye

School of Mathematics and Statistics at Fujian Normal University, Peoples Rep of China

Abstract:

In this paper, we study the weak differentiability of global strong solution of stochastic differential equations, the strong Feller property of the associated diffusion semigroups and the global stochastic flow property in which the singular drift b and the weak gradient of Sobolev diffusion σ are supposed to satisfy $\|b(x)1_{|x|\leq R}\|_{p_1} \leq O((\log R)^{(p_1-d)^2/2p_1^2})$ and $\|\nabla\sigma(x)1_{|x|\leq R}\|_{p_1} \leq O((\log(R/3))^{(p_1-d)^2/2p_1^2})$ respectively. The main tools for these results are the decomposition of global two-point motions, Krylov's estimate, Khasminskii's estimate, Zvonkin's transformation and the characterization for Sobolev differentiability of random fields.

Special Session 20 : Lie Symmetries, Conservation Laws, and Other Approaches in Solving Nonlinear Differential Equations

Organizer(s): Chaudry Masood Khalique , Wen-Xiu Ma , Maria Luz Gandarias

Introduction: This session is devoted to research areas that are related to nonlinear differential equations and their applications in science and engineering. The main focus of this special session is on the Lie symmetry analysis, conservation laws and their applications to ordinary and partial differential equations. Other approaches in finding exact solutions to nonlinear differential equations will also be discussed. This includes, but not limited to, asymptotic analysis methodologies, the simplest equation method, the multiple exp-function method, inverse scattering transform techniques, the upper-lower solutions method, the Hirota method, and others.

Totally non-negative Pfaffian and its constructions

Schedule: July 8 17:30-18:00 Room 641

Jen-Hsu Chang

National Defense University, Taiwan

Co-Author(s): Jen-Hsu Chang

Abstract:

The totally non-negative pfaffian (TNNP) is define for a skew-symmetric matrix such that all the sub-pfaffians are non-negative. It appears in the pfaffian structure of tau-function for the non-singular web solitons of the BKP equation . One constructs TNNP using the Perfect matching, chord diagram and the Dyck paths enumeration. Its tridiagonal form is also investigated.

A study of a fourth-order nonlinear generalized Ablowitz-Kaup-Newell-Segur water wave equation in fluid dynamics

Schedule: July 9 8:00-8:30 Room 641

Chaudry M Khalique

North-West University, So Africa

Abstract:

In this talk we study a fourth-order nonlinear generalized Ablowitz-Kaup-Newell-Segur water wave equation in fluid dynamics. Utilizing the Lie theoretic approach, symmetries of the equation are obtained and then used to construct invariant solutions. Conclusively, we derive conserved quantities of the equation by employing both the general multiplier and Noether techniques.

Unsteady analysis of heat transfer and injection--driven flow in a vertical filter chamber

Schedule: July 9 14:00-14:30 Room 641

Modisawatsona Lucas ML Lekoko

North West University, So Africa

Co-Author(s): Modisawatsona Lucas Lekoko, Gabriel Magalakwe, Shina Daniel Olonijju

Abstract:

The transition between steady and unsteady state regimes plays a vital role during filtration. The current study considers a theoretical investigation of the advancement into an unsteady state regime of flow and heat transfer dynamics in a vertical chamber. The study examines the effects of the time dependent inflow velocity on the internal flow and energy dynamics. Graphical representations of the time evolution of the flow speed, pressure and temperature are analyzed. Also, the impacts of the flow and heat parameters on the skin friction, Nusselt number and average vertical wall pressure are studied. The results indicate that as time evolves, permeates production increases because speed, internal work, and pressure intensify with time. In addition, to aid internal flow, high injection rate, suction rate, Richardson number and Stuart number are ideal during operation because these parameters minimize the overall friction of the filter chambers walls.

Reduced integrable equations and Darboux transformations

Schedule: July 8 16:30-17:00 Room 641

Wen-Xiu Ma

University of South Florida, USA

Abstract:

We will explore new integrable equations via similarity transformations. Lax pairs will be used to derive reduced integrable equations, their binary Darboux transformations, and soliton solutions generated from the zero seed. Representative examples include reduced matrix nonlinear Schrödinger equations and modified Korteweg-de Vries equations.

Lie Symmetry Analysis of Pressure-Driven 3D Filtration Flow

Schedule: July 9 13:30-14:00 Room 641

Gabriel G Magalakwe

North-West University, So Africa

Co-Author(s): Gabriel Magalakwe, Itumeleng Thabo

Abstract:

Filtration systems play a fundamental role in a wide range of industrial and biomedical applications, where fluid transport through porous media is predominantly driven by pressure gradients. This study presents an analytical investigation of three-dimensional filtration flow under both linear and oscillatory pressure conditions, with the aim of advancing the theoretical understanding of such systems. The governing continuity and Navier-Stokes equations, describing momentum and pressure variations, are solved using Lie symmetry analysis to obtain closed-form expressions for the velocity and pressure fields within the filter chamber. These analytical solutions are subsequently utilised to examine the behaviour of momentum and pressure distributions throughout the system. The results demonstrate that linear pressure gradients generate stable and predictable flow patterns, while oscillatory pressure gradients mitigate clogging effects and enhance filtration efficiency. Overall, the findings provide valuable theoretical insights for optimising outflow and improving the performance of filtration systems.

Solutions and conservation laws of a (3+1)-dimensional Zakharov-Kuznetsov equation

Schedule: July 9 8:30-9:00 Room 641

Lethogonolo LD Moleleki

North-West University, So Africa

Co-Author(s): B. Muatjetjeja, A.R. Adem

Abstract:

In this talk, we study a nonlinear evolution partial differential equation, namely the (3+1) dimensional Zakharov Kuznetsov equation. Kudryashov method together with Jacobi elliptic function method is used to obtain the exact solutions of the (3+1) dimensional Zakharov Kuznetsov equation. Furthermore, the conservation laws of the (3+1) dimensional Zakharov Kuznetsov equation are obtained by using the multiplier method.

Role of OpenFOAM in Computational Fog Dynamics

Schedule: July 9 9:30-10:00 Room 641

Noor Muhammad

King Fahd University of Petroleum and Minerals, Saudi Arabia

Co-Author(s): Noor Muhammad, Taha Aziz, Haitham M.S. Bahaidarah

Abstract:

Condensation occurs when the air temperature drops to its dew point, causing water vapors in the air to cool, lose kinetic energy, and transform into liquid droplets. This process is influenced by the relative humidity and temperature fluctuations, where lower temperatures reduce the air's capacity to hold water vapor, resulting in the formation of liquid water droplets on cooler surfaces. The condensation process is fundamental to the operation of fog harvesting systems, where specialized meshes capture the transformed water droplets. However, the behavior of droplets attached to meshes under background airflow is not well understood. Consequently, controlling the motion and merging of these droplets with neighboring ones poses a significant challenge. In this study, for fog airflow, it is demonstrated that droplets on parallel meshes can aerodynamically interact with both downstream and upstream neighbors at different temperatures. These interactions lead to diverse behaviors, including alignment, coalescence, and repulsion. This study explores the key factors influencing the efficiency of material and design used for fog harvesting systems, and environmental conditions such as fog density and wind speed. The dynamical model includes the single-phase transport equation along with the $k - \Omega$ SST (Shear Stress Transport (SST) k -omega) a subclass of RAS (Reynolds-Averaged Simulation) model. The computational analysis of fog harvesting mesh for water collection is performed in OpenFOAM (Open-source Field Operation And Manipulation). The Finite Volume Method (FVM) is employed for solution of the model to check the efficiency and effectiveness of fog harvesting computational designs. Using OpenFOAM, condensation, alignment and merging behaviors based on the interactions between wakes and droplets are visualized. The computational design enhances the surface area available for fog capture, thereby increasing the droplets collection efficiency and resulting in a higher yield of liquid water. The computational results obtained in this study can lead to more sustainable and efficient fog water collectors.

Approximate Symmetry Methods with Applications

Schedule: July 8 17:00-17:30 Room 641

Mehmet Pakdemirli

Manisa Celal Bayar University, Turkey

Abstract:

Three common approximate symmetry methods with the newly proposed additional three methods are briefly discussed. Exact and approximate symmetry generators are calculated for sample ordinary and partial differential equations. The first three methods and the new three methods are contrasted within each other as well as with the exact symmetries. The characteristic features of the methods are exploited using sample problems. Approximate solutions are found using the various approximate symmetry theories and contrasted with each other and with the exact solutions.

The Invariance, Conservation Laws and Integeation of Differential Equations

Schedule: July 9 9:00-9:30 Room 641

Ali Raza

Stellenbosch University, So Africa

Co-Author(s): Sibusiso Moyo, F.M. Mahomed, F.D. Zaman, A.H. Kara

Abstract:

In this talk, we begin with symmetry classification for a class of nonlinear PDEs using the Lie symmetry method and discuss the fundamental simplifications of variables that arise from the Lie invariance criterion. Following this, we discuss the construction of the optimal system of subalgebras to identify unique group-invariant solutions via reductions under optimal system.

Special Session 22 : Models of emergence and collective dynamics

Organizer(s): Roman Shvydkoy , Ewelina Zatorska

Introduction: Emergence is a phenomenon of self-organization in systems governed by local interactions between agents. It appears relevant in many different contexts including swarming behavior of animals, technological applications such as control, as well as social networking. This session will highlight new research developments in the subject and aims to gather specialists working on a broad range of models of collective dynamics on agent-based, kinetic, and hydrodynamic levels of description.

On weak solutions to self-organized systems of Euler-type with non-constant interaction kernel

Schedule: July 7 8:30-9:00 Room 421

Cleopatra Christoforou

University of Cyprus, Cyprus

Co-Author(s): Debora Amadori

Abstract:

We present recent results on the existence and long-time asymptotic behavior of solutions to a hydrodynamic model of flocking-type with pressure, within the framework of weak solutions. The analysis is carried out in one spatial dimension, considering both all-to-all interaction kernel and non-constant kernel in a periodic domain. For entropy weak solutions on the torus, we establish exponential decay in time toward a flocking state in the L^2 norm, under the assumptions of an integrable interaction kernel and a density uniformly bounded away from vacuum. The approach relies on the front-tracking approximate solutions, the relative entropy and a suitable energy functional.

Finite speed of propagation in the one-dimensional pressureless Euler alignment system

Schedule: July 6 17:00-17:30 Room 421

Szymon Cygan

University of Heidelberg, Poland

Co-Author(s): Szymon Cygan, Bartosz Drzygala, Grzegorz Karch

Abstract:

In this talk, I will present recent results on the one-dimensional pressureless Euler alignment system with a strongly singular interaction kernel and initial data allowing vacuum $\begin{aligned} \rho_t + (\rho u)_x &= 0, \quad u_t + u u_x = -\Lambda^\alpha (\rho u) + u \Lambda^\alpha \rho. \end{aligned}$ Building on a previously developed framework for the case $\alpha \in (0, 1)$, we extend the analysis to the full range $\alpha \in (0, 2)$. We work under the structural condition imposed on the initial data, $\begin{aligned} 0 \leq G_0(x) \leq a, \quad \rho_0(x) \quad \text{where} \quad G_0 = \partial_x u_0 - \Lambda^\alpha \rho_0, \end{aligned}$ which determines an admissible class of initial velocity profiles and is propagated by the dynamics. I will discuss the construction of global weak solutions corresponding to compactly supported initial data and show that the support remains compact for all times. Moreover, I will explain how finite speed of propagation can be established by adapting barrier arguments and contact analysis techniques from the theory of nonlocal porous medium equations.

On the incompressible limit for a viscoelastic tumour growth model.

Schedule: July 6 16:30-17:00 Room 421

Tomasz Debiec

University of Warsaw, Poland

Abstract:

I will discuss some approaches to mathematical modelling of living tissues, with application to tumour growth. In particular, I will describe recent results on the incompressible limit (or stiff-pressure limit) for a compressible model, building a bridge between density-based description and a geometric free-boundary problem by passing to the singular limit in the pressure law. We set out from a two-species advection-reaction system --- the cell densities are advected by the gradient of a chemical potential which satisfies the so-called Brinkman law, while the growth rate of each population is governed by a function of the joint population pressure. In the limit problem the total population density is limited to a critical value and the pressure vanishes on unsaturated regions.

Stick with me, naturally: from Cucker--Smale to Euler-alignment through gradient flows

Schedule: July 6 15:00-15:30 Room 421

Sondre T Galtung

SINTEF, Norway

Abstract:

This talk presents a new perspective on the one-dimensional pressureless Euler-alignment system, which can be seen as a hydrodynamic limit of the Cucker--Smale model for collective behaviour. While previous analyses of the Cucker--Smale model typically allowed particle trajectories to cross, recent works by Leslie and Tan suggest that such solutions are not suitable for hydrodynamic limits, and instead advocate for sticky particle dynamics. Building on this perspective, we characterise the sticky particle Cucker--Smale dynamics as an L^2 -gradient flow of a convex functional, providing a new variational framework for the system. This approach not only recovers the unique entropy solution of the associated scalar balance law in Leslie and Tan's framework, but also clarifies how (non-)monotonicity properties of the model's so-called natural velocities determine cluster formation. Our results place the Euler-alignment system within a rigorous gradient flow framework in one dimension, already established for the pressureless Euler and Euler--Poisson systems.

A collective dynamics perspective on transformer dynamics beyond gradient flows

Schedule: July 6 17:30-18:00 Room 421

Nicolas Garcia Trillos

University of Wisconsin Madison, USA

Co-Author(s): Sixu Li (UW-Madison), Jan Peszek (Warsaw), Trevor Teolis (Rice), Konstantin Riedl (Oxford), Jake Maranzatto (Maryland), Semih Akkoc (Maryland), and Sennur Ulukus (Maryland)

Abstract:

In this talk, I will discuss a collective dynamics perspective on transformers, the architecture at the heart of modern large language models. In particular, we will discuss how dimensionality reduction techniques akin to those used in the study of the Kuramoto model can be employed to explore the rich structure that the evolution of the distributions of tokens (particles) can have when selecting different values for the key, query, and value matrices parameterizing a transformer model consisting of compositions of multiple self-attention layers. This perspective will allow us to explore token dynamics beyond the gradient flow setting obtained by very specific choices of model parameters and to uncover parameter choices inducing cyclical behavior, consensus formation without stability, and Hamiltonian dynamics. While our theoretical discussion will focus exclusively on 2-dimensional token embeddings, I will also discuss numerical experiments that suggest that our theoretical findings can be extrapolated to general multi-dimensional settings.

A new formula for the Wasserstein distance between solutions to (nonlinear) continuity equations

Schedule: July 7 9:00-9:30 Room 421

Piotr Gwiazda

Institute of Mathematics Polish Academy of Sciences, Poland

Abstract:

Given two continuity equations with density-dependent velocities, we provide a new formula for the Wasserstein distance between the solutions in terms of the difference of velocities evaluated at the same density. The formula is particularly attractive to deduce quantitative estimates and rates of convergence for singular limits. We illustrate it using several examples. For the porous medium equation with exponent m , we prove that solutions are Lipschitz continuous with respect to m , providing a quantitative version of the result of Benilan and Crandall. This result can be extended to a general aggregation-diffusion equation.

On a Cross-Diffusion System with Independent Drifts and no Self-Diffusion: Mixing Dynamics

Schedule: July 7 9:30-10:00 Room 421

Alpar R Meszaros

Durham University, England

Abstract:

We present a global existence theory for weak solutions to a two-species cross-diffusion system, in one space dimension, in which the evolution of each species is governed by two mechanisms: a diffusion which acts only on the sum of the species with a logarithmic or fast diffusion type pressure law, and a drift term, which can differ between the two species. We will discuss two types of phenomena, regarding qualitative properties of solutions. First, we will show that if the initial densities are 'totally mixed', this property will propagate over time. Second, we will show how to remove the this condition on the initial data, resulting in weak solutions which can be only partially mixed. All these solutions are in contrast with the segregated solutions, known previously in the literature. The talk will be based on joint works with Guy Parker (Durham).

Self-Attention as a Multi-Agent System: a Dynamical Perspective on Transformers

Schedule: July 6 14:30-15:00 Room 421

Jan Peszek

University of Warsaw, Poland

Abstract:

Transformers, the architecture underlying modern large language models, (specifically its self-attention component) was recently recast as the multi-agent system
$$\dot{x}_k(t) = \operatorname{P}^\perp_{x_k(t)} \left(\sum_{j=1}^n \exp \left(\langle Qx_k(t), Kx_j(t) \rangle \right) Vx_j(t) \right), \quad k=1, \dots, n,$$
 where $x_k(t) \in \mathbb{S}^{d-1}$ represents the state of the k -th token after the t -th attention layer and $Q, K, V \in \mathbb{R}^{d \times d}$ are the trained query, key and value matrices and $P_{x_k(t)}^\perp$ is the projection onto $\mathbb{S}^{d-1}$. The output of the model is determined by the long-time state of the system, making its asymptotic behavior a central object of study. The goal of this talk is to illustrate how methods from collective dynamics can help analyze large language models. In this talk I present a dynamical systems perspective on a 2D linearized transformer architecture, where the evolution of tokens across attention layers can be reformulated as a Kuramoto-type interacting particle system. Using the Ott-Antonsen ansatz, the high-dimensional dynamics admits a low-dimensional reduction describing the evolution in a reduced vocabulary regime. I will focus on the stability of the reduced dynamics and how their behavior persists beyond the Ott-Antonsen resulting in the stability of the full particle system.

Mean field limit of non exchangeable interacting diffusions on co-evolutionary networks

Schedule: July 6 18:30-19:00 Room 421

David Poyato

University of Granada, Spain

Co-Author(s): Julián Cabrera-Nyst

Abstract:

Traditional models of interacting particle systems often assume a fixed network of connections, which simplifies the analysis but fails to capture many real-world phenomena. Indeed, interacting particles where the network structure and particle states co-evolve in mutual influence, are increasingly recognised as essential in diverse fields. For instance, they appear in neuroscience, where learning is encoded through the strengthening and weakening of synaptic connections. In this talk I will present the rigorous mean-field limit for systems of non-exchangeable interacting diffusions on co-evolutionary networks. The main challenge arises from the coupling between the network dynamics and the agents' states, which results in a non-Markovian dynamics where the system's future depends on its entire history. Consequently, the mean-field limit is not described by a partial differential equation, but by a system of non-Markovian stochastic integrodifferential equations. A second difficulty stems from the non-linear weight dynamics, which requires a careful choice for the limiting network structure. Due to the limitations of the classical theory of graphons (Lovász and Szegedy, 2006), in our mean-field limit we employ for the first time K-graphons (Lovász and Szegedy, 2010), also termed probability-graphons (Abraham, Delmas, and Weibel, 2025), as they provide a natural framework compatible with non-linear structures.

Evolution of Correlation in Simple Models

Schedule: July 6 14:00-14:30 Room 421

Keith Promislow

Michigan State University, USA

Co-Author(s): Adam Petrucci and Vinh Nguyen

Abstract:

We present particle-based models for cell cycle evolution that possess asymmetrical forcing and for collections of water molecules that interact through a dipole moment (Stockmayer model). We show that both systems have some degree of mean-field limit. In the cell cycle model, we examine the temporal evolution of measures of correlation starting from weakly correlated initial data and compare particle evolution to solutions of the corresponding Vlasov system. In the Stockmayer model we examine the scaling of dipole length with particle number N that yields a mean-field scaling, and show that the dipolar properties of water uncouple from the fluid properties in the mean field.

Graph-induced rotational twisted states in systems of identical oscillators

Schedule: July 7 13:30-14:00 Room 421

David N Reynolds

University of Warsaw, Poland

Co-Author(s): Nastassia Pouradier Duteil, David Poyato

Abstract:

The study of fish behavior and the phase-transition between milling (rotations) and schooling (velocity alignment) has given rise to the current study. Milling behavior in second order systems has been successfully modeled, but largely induced by the combination of self-propulsion and friction forces coupled with attraction and repulsion forces. We investigate the feasibility of producing phase-transitions between milling and schooling via heterogeneities in an alignment operator, as opposed to the attraction and repulsion forces used previously. In this talk we present results on first-order oscillatory models which under certain graph structures produce bi-stability of the rotational states indicative of milling, and fully synchronized states indicative of schooling.

Global solutions to cross-diffusion systems with independent advections in one dimension

Schedule: July 7 15:00-15:30 Room 421

Jakub Skrzeczkowski

University of Oxford, England

Abstract:

We consider cross-diffusion systems describing evolution of two species u and v moving according to Darcy's law with the pressure law $p(s) = \frac{1}{\alpha-1}s^{\alpha-1}$ where $s = u + v$. One of the most challenging questions in the field is the construction of solutions to the problem in the presence of additional advection fields, without imposing any artificial structure on the fields or the initial conditions. Although advection arises naturally in these models, it breaks the symmetry of the system and prevents application of techniques developed in recent years. Here, we provide a new approach to construct solutions in one space dimension that works in a unified manner for all pressure exponents $\alpha \in (0, \infty)$ and for arbitrary initial data. In particular, in the regime $\alpha > 1$, this yields the first existence result of its kind, obtained without any structural assumptions. We construct the solutions as a limit of a vanishing viscosity approximation $(u_\varepsilon, v_\varepsilon)$. The main challenge is to identify the limit of $u_\varepsilon \partial_x p(s_\varepsilon)$, where $s_\varepsilon = u_\varepsilon + v_\varepsilon$. The key new insight is that possible oscillations of u_ε and $\partial_x p(s_\varepsilon)$ are correlated, simplifying the Young measure analysis in the compensated compactness argument and allowing identification of the limit. Somewhat surprisingly, in contrast to the theory of 2×2 hyperbolic systems, the argument relies on only three entropy-entropy flux pairs. This is particularly useful for $\alpha > 2$, where it is unclear whether additional entropies are available.

Relative entropy method for non-local models

Schedule: July 7 15:30-16:00 Room 421

Agnieszka Swierczewska-Gwiazda

University of Warsaw, Poland

Abstract:

We will discuss Euler-Poisson and Euler-Korteweg systems with friction and exponential pressure. Our interest is directed to strong solutions of the Keller-Segel system and Cahn-Hilliard, which are high-friction limits of the dissipative measure-valued solutions to the hydrodynamic systems. For the passage to the limit system, we use the highly efficient approach of the relative entropy method, which found use in a various different fields, ranging from weak-strong uniqueness problems, to stability studies, asymptotic limits and dimension reduction problems.

Collective dynamics with nonlinear velocity alignment

Schedule: July 6 13:30-14:00 Room 421

Changhui Tan

University of South Carolina, USA

Abstract:

I will discuss recent developments in flocking models with nonlinear velocity alignment, focusing on the role of nonlinearity in the emergence of collective behavior, with quantitative estimates and rates.

From Nanbu Particle Systems to Transformer Approximations of Boltzmann Solutions

Schedule: July 6 18:00-18:30 Room 421

Trevor Teolis

Rice University, USA

Co-Author(s): Trevor Teolis, Maarten de Hoop

Abstract:

We show that solutions of the Boltzmann equation can be uniformly approximated, in suitable Wasserstein metrics, by measure-theoretic transformer models. Our approach is based on a pushforward representation of Boltzmann dynamics induced by the Nanbu stochastic particle system, in which the evolution of a tagged particle depends on an underlying context consisting of the initial velocity distribution and a Poisson random measure encoding collision events. In this formulation, the fundamental objects (or tokens) consist of velocity-path pairs, where the paths are Radon measures describing jump sequences. By exploiting this structure, we place the Boltzmann pushforward representation within the scope of recent universality results for measure-theoretic transformers.

On Models of Self-Organized Dynamics and the Euler Equations

Schedule: July 7 14:30-15:00 Room 421

Konstantina Trivisa Trivisa

University of Maryland, USA

Abstract:

In this lecture I will present results on models describing self organized dynamics and discuss their relation to the Euler equations for compressible fluids.

On integrability properties of Euler-Riesz systems

Schedule: July 6 15:30-16:00 Room 421

Athanasios Tzavaras

KAUST/Applied Mathematics and Computational Science, Saudi Arabia

Abstract:

We consider the system of compressible Euler equations augmented with nonlocal term associated to a Riesz potential. This system emerges as a critical point of an action functional. Also it is equipped with a stress tensor that may be expressed in two distinct representations and gives rise to an associated bilinear fractional integral operator. We establish a uniform estimate for a bilinear fractional integral operator via restricted weak-type endpoint estimates and Marcinkiewicz interpolation. The estimate leads to integrability analysis of the associated stress-tensor. In addition, using the theory of compensated integrability it yields a gain in integrability for finite-energy solutions. Finally, for smooth periodic solutions of the reformulated system, we derive a stability result (joint work with N. Alves (KAUST) and L. Grafakos (Univ. of Missouri)).

On the weak solution of the uni-directional Euler-alignment system with strongly singular communication

Schedule: July 7 14:00-14:30 Room 421

Liutang Xue

Beijing Normal University, China, Peoples Rep of China

Abstract:

We talk about the recent development on the weak solution for the Euler-alignment system in d dimensions with unidirectional flows and strongly singular communication protocols. A main part is via the modulus of continuity method.

Special Session 23 : Evolution Equations and Integrable Systems

Organizer(s): Alex Himonas , Curtis Holliman , Fangchi Yan

Introduction: Linear and nonlinear evolution equations have been at the forefront of advances in partial differential equations for a long time. They are involved in beautiful, yet extremely challenging problems, with a strong physical background, for which progress is achieved through a mixture of techniques lying at the interface between analysis and integrable systems. Topics studied for these equations include, among others, traveling waves, initial-boundary value problems, local and global well-posedness, inverse scattering, stability, and integrability.

Scattering for radial solutions of focusing supercritical wave equations

Schedule: July 6 18:00-18:30 Room 312

Guher Camliyurt

Virginia Tech, USA

Co-Author(s): Carlos Kenig

Abstract:

This talk mainly focuses on the scattering of radial bounded solutions to focusing semi-linear wave equations with energy supercritical nonlinearity in four dimensions. We first review earlier applications of the concentration compactness and rigidity methods in energy-critical and energy-supercritical settings. As most of these results address the problem in three dimensions, we explore the unique challenges posed by analogous problems in even dimensions. We then investigate how rigidity arguments, originally developed for three dimensions and successfully generalized to higher odd dimensions, can be adapted to address these new difficulties in even-dimensional settings.

Linear Evolution Equations Revisited via the Fokas Unified Transform Method

Schedule: July 7 9:30-10:00 Room 312

Andreas Chatziafratis

National and Kapodistrian University of Athens, Greece

Abstract:

We survey some of our recent research results relating to construction of explicit solutions (closed-form integral representations), in the classical sense, as well as to qualitative theory for non-homogeneous initial-boundary-value and interface problems for a variety of linear (systems of) evolution partial differential equations (PDE) with constant and with variable coefficients. Such PDE emerge in connection to a plethora of natural phenomena and mathematical models in physics, biology, chemical engineering, finance and other applied sciences; examples include continuum mechanics, heat transfer, biomedicine, electron optics, and battery technology. Our research program relies on, explores and extends the applicability of the celebrated complex-analytic unified transform method of Fokas. This is joint work with a large global network of collaborators. Notable findings include: long-range instabilities (see e.g. [A. Chatziafratis, T. Ozawa, S.-F. Tian, Rigorous analysis of the unified transform method and long-range instabilities for the inhomogeneous time-dependent Schrödinger equation on the quarter-plane, *Math. Annalen*, 2023] and [A. Chatziafratis, L. Grafakos, S. Kamvissis, Long-range instabilities for linear evolution PDE on semi-bounded domains via the Fokas method, *Dyn. PDE*, 2024]), time-asymptotic break-down effects (e.g. [J.L. Bona, A. Chatziafratis, H. Chen, S. Kamvissis, The linear BBM-equation on the half-line revisited, *Lett. Math. Phys.*, 2024]), and counter-examples to solution uniqueness (e.g. [A. Chatziafratis, A. Miranville, G. Karali, A.S. Fokas, E.C. Aifantis, "Higher-order diffusion and Cahn-Hilliard-type models revisited on the half-line", *Math. Models Methods Appl. Sci.*, 2025] and [A. Chatziafratis, S. Kamvissis, Infinity of solutions to initial-boundary value problems for linear constant-coefficient evolution PDEs on semi-infinite intervals, *Bull. London Math. Soc.*, 2025])

The nonlinear Schrödinger equation on the half-space

Schedule: July 6 14:00-14:30 Room 312

Alex Himonas

University of Notre Dame, USA

Co-Author(s): Fangchi Yan

Abstract:

This work studies the initial-boundary value problem for both the linear Schrödinger equation and the cubic nonlinear Schrödinger equation on the half-space in higher dimensions ($n \geq 2$). First, the forced linear problem is solved on the half-space via the Fokas method and then using the obtained solution formula new and interesting linear estimates are derived with data and forcing in appropriate spaces. Second, the well-posedness of the nonlinear problem on the half-space is proved with initial data in Sobolev spaces $H^s(\mathbb{R}_+^n)$, with $s > \frac{n}{2} - 1$, and boundary data in natural Bourgain spaces $\mathcal{B}^s$ that reflect the boundary regularity of the linear problem. The proof method consists of showing that the iteration map defined via the Fokas solution formula is a contraction by establishing sharper trilinear estimates. The presence of the boundary introduces solution spaces that involve temporal Bourgain spaces.

A Predictive Framework for Glioblastoma Progression

Schedule: July 7 9:00-9:30 Room 312

Curtis A Holliman

The Catholic University of America, USA

Co-Author(s): Francesca Cozzi

Abstract:

Glioblastoma remains one of the most challenging malignancies to treat, owing in part to its aggressive and heterogeneous progression. Developing reliable predictive frameworks for tumor dynamics has the potential to inform clinical decision-making and improve patient outcomes. In this talk, we present a computational approach to modeling glioblastoma progression, integrating mathematical and data-driven techniques to capture key features of tumor behavior. We discuss the theoretical foundations of our framework, its predictive capabilities, and directions for future development.

On Special Properties of Solutions to the Benjamin-Bona-Mahony Equation

Schedule: July 6 15:00-15:30 Room 312

Christian Hong

University of California Santa Barbara, USA

Co-Author(s): Gustavo Ponce

Abstract:

This work is concerned with the Benjamin-Bona-Mahony equation. This model was deduced as an approximation to the Korteweg-de Vries equation in the description of the unidirectional propagation of long waves. Our goal is to present some results on unique continuation and regularity properties of solutions to the associated initial value problem and initial periodic boundary value problems.

Hamiltonian Transformation Theory and Dispersive PDEs

Schedule: July 6 18:30-19:00 Room 312

Adilbek Kairzhan

Nazarbayev University, Kazakhstan

Co-Author(s): Philippe Guyenne, Catherine Sulem

Abstract:

In this talk, we present the derivation of a Hamiltonian Dysthe equation for the slowly varying envelope of modulated wavetrains based on a Hamiltonian formulation of the water wave problem and by applying techniques from Hamiltonian theory. The models we consider include 2d and 3d surface gravity waves and 2d water waves with constant vorticity. Our method provides a procedure to reconstruct the surface elevation from the wave envelope, based on the Birkhoff normal form transformation to eliminate all non-resonant triads. The talk is based on a series of works with Catherine Sulem (University of Toronto) and Philippe Guyenne (University of Delaware).

Integral solutions of evolution equations

Schedule: July 6 14:30-15:00 Room 312

Konstantinos Kalimeris

Academy of Athens, Greece

Abstract:

In this talk we consider initial-boundary value problems (IBVPs) for linear evolution partial differential equations (PDEs) with time-dependent coefficients. We present (for the first time) integral representations of solutions for a big family of these problems; the derivation of these solutions is based on extensions of the unified transform (UT). Based on these solutions we discuss the well-posedness of these IBVPs for certain linear and non-linear PDEs. Finally, we show that, for certain evolution partial PDEs, the solution of IBVPs on a finite interval can be reconstructed as a superposition of solutions to two associated IBVPs posed on the half-line, which provides a completely new perspective on studying this large class of problems.

Stokes Phenomenon in CR geometry

Schedule: July 7 8:30-9:00 Room 312

Ilya Kossovskiy

Southern University of Science and Technology, Peoples Rep of China

Abstract:

In our joint work with Shafikov (JEMS, 2016), we proved that the formal versus holomorphic equivalence problems in CR geometry are distinct. This shows, in particular, that CR geometry enjoys the Stokes Phenomenon: the existence of additional holomorphic invariants supplementing a formal normal form. Describing the Stokes phenomenon explicitly has been an open problem since then. In our joint work with Laurent Stolovitch, we make a significant progress in solving this problem. In particular, we show that the respective (formal versus holomorphic) moduli space of analytic CR hypersurfaces in $\mathbb{C}^2$ is, somewhat surprisingly, finite-dimensional (and generically empty). The construction that we use is based on the Multisummability theory in Dynamical Systems.

The complex Ginzburg-Landau equation on a finite interval and chaos suppression via a finite-dimensional boundary feedback stabilizer. Part I: Well-posedness

Schedule: July 6 17:00-17:30 Room 312

Dionyssios Mantzavinos

University of Kansas, USA

Co-Author(s): Turker Ozsari, Kemal Cem Yilmaz

Abstract:

This is the first of two talks on the well-posedness and boundary stabilization of the initial-boundary value problem for the complex Ginzburg-Landau equation on a finite interval. This first talk focuses on the well-posedness of the open loop model. More precisely, it establishes a local well-posedness theory for the open loop model in L^2 -based fractional Sobolev spaces in the case of Dirichlet-Neumann type inhomogeneous mixed boundary conditions. This local well-posedness result is based on linear estimates derived by using the weak solution formula obtained via the unified transform (also known as the Fokas method). The global well-posedness properties of the open loop model in the presence of inhomogeneous boundary conditions are also discussed. In a sequel talk by Turker Ozsari, the results discussed here for the open loop model will be employed for the analysis of the rapid boundary feedback stabilization problem and the design of a nonlocal controller via a finite number of Fourier modes of the state of solution.

The complex Ginzburg--Landau equation on a finite interval and chaos suppression via a finite-dimensional boundary feedback stabilizer. Part II: Control

Schedule: July 6 17:30-18:00 Room 312

Turker Ozsari

Bilkent University, Turkey

Co-Author(s): Dionyssios Mantzavinos; Kemal Cem Yilmaz

Abstract:

This is the second of two talks on well-posedness and boundary stabilization for the complex Ginzburg--Landau (CGL) equation on a finite interval. In the prequel talk (D. Matzavinos, Part I), the open-loop Dirichlet--Neumann initial-boundary value problem is shown to be locally (and, in suitable regimes, globally) well posed at low regularity via sharp spatiotemporal estimates obtained from a unified-transform (Fokas method) representation formula. Building on those estimates, I present a rapid boundary feedback stabilization (chaos suppression) scheme using Neumann actuation: a nonlocal controller depending only on finitely many Fourier modes, based on a slow--fast decomposition into a finite-dimensional "slow" part and a rapidly decaying tail. We quantify (i) how many modes guarantee exponential stabilization at a prescribed decay rate, and (ii) the minimal number ensuring stabilization at some exponential rate. Closed-loop well-posedness follows locally by combining Part I spatiotemporal bounds with the feedback structure, while global energy solutions are obtained from the stabilization estimates. Uniqueness is derived by reducing to a homogeneous-boundary problem through a bounded, invertible Volterra-type integral transform on Sobolev spaces. Numerical simulations illustrating chaos suppression will also be discussed. This research was supported by TUBITAK 1001 Grant 122F084.

Regularity of solution of periodic evolution equations

Schedule: July 6 13:30-14:00 Room 312

Beatrice Pelloni

Heriot-Watt University, Scotland

Co-Author(s): Lyonell Boulton

Abstract:

I will discuss the regularity of solution of periodic evolution equations starting from an initial condition of low regularity. Specifically, I will present many more general instances of what was known as the Talbot effect, that is felt as an echo of the linear effect also in the solution on nonlinear problems.

Waves in cosmological background with static Schwarzschild radius in the expanding universe

Schedule: July 7 8:00-8:30 Room 312

Karen Yagdjian

University of Texas Rio Grande Valley, USA

Abstract:

The latest astrophysical observational data confirm that the universe is expanding with acceleration and that the masses of the black holes are changing over time. This raises the question of the solutions to partial differential equations that model the propagation of waves in a cosmological background with black holes in an expanding universe. We prove the existence of global in time small data solutions of semilinear Klein-Gordon equations in space-time with a black hole with time-dependent mass and static Schwarzschild radius in the expanding universe. We indicate that the damping term of the covariant Klein-Gordon equation is independent of location in the background only if the mass of the black hole is proportional to the scale factor of expansion. This is where the cosmological principle comes into play.

A higher order cubic NLS equation on the half-line

Schedule: July 6 15:30-16:00 Room 312

Fangchi Yan

Virginia Tech, USA

Co-Author(s): Alex Himonas

Abstract:

This work studies the initial-boundary value problem on the half-line for the cubic nonlinear Schrödinger equation with a dispersion of order $m = 2, 4, \dots$. The main result obtained is the optimal well-posedness of this problem when the initial data belong in the spatial Sobolev spaces $H^s(0, \infty)$, $s > -\frac{1}{4}m + \frac{1}{2}$, and the boundary data belong in appropriate temporal Sobolev spaces suggested by the time regularity of the linear problem. The proof is based on the Fokas solution formula for the forced linear problem and the linear estimates obtained for this solution in Bourgain spaces. Deriving sharp trilinear estimates suggested by the linear estimates and then applying them, it is shown that the iteration map defined by the Fokas solution formula is a contraction in an appropriate solution space.

Special Session 24 : Mathematical and Computational Modeling of Complex Biological Systems

Organizer(s): Zhisheng Shuai , Michael Li , Samares Pal

Introduction: The study of complex biological systems involves multiple spatial and temporal scales, presenting significant analytical and practical challenges. To tackle these challenges, researchers leverage advanced mathematical and computational methods to gain deeper insights into biological dynamics. This special session serves as a forum for scholars engaged in developing and applying these approaches in mathematical biology. By showcasing recent research advancements, the session aims to foster discussions, collaboration, and innovation, ultimately advancing both theoretical methodologies and real-world applications in this evolving field.

An immuno-epidemiological model with consideration for symptom score

Schedule: July 10 11:30-12:00 Room 432

Summer Atkins

The University of Alabama in Huntsville, USA

Co-Author(s): Summer Atkins (The University of Alabama in Huntsville), Binod Pant (Northeastern University), and Hana Dobrovolny (Texas Christian University)

Abstract:

The incorporation of human behavior into epidemiological modeling has been quite a popular topic as of late, and there are many effective ways to mathematically introduce behavior into such models. In this talk, we incorporate behavior into an epidemiological model for an upper respiratory infectious disease based upon an assumption that the sicker an individual feels the more likely they will reduce their contacts. Our methodology in capturing this behavioral assumption will be through a nested-multiscale modeling approach. The within-host dynamics of a symptomatic individual is represented by a system of ordinary differential equations in which one of the compartments measures the symptom score of the infected individual. This model is then linked to an age-structured between-host model (where age represents time since infection) by having a reduction in contact rate be a function that depends on the individual's symptom score. In this talk, we present a flowchart of the model, some of the analytical results, and some simulations. In our simulations, we vary parameters of the linking function to investigate how the transmission dynamics change based on how reactive an individual is to their symptoms.

On the influence of diffusion strategies on the average population levels and competition outcomes

Schedule: July 10 13:30-14:00 Room 432

Elena Braverman

University of Calgary, Canada

Co-Author(s): Andrzej Rickes, Jennifer Lawson

Abstract:

In 2006, Lou proved that, once the intrinsic growth rate r in the logistic model is proportional to the spatially heterogeneous carrying capacity K ($r = K^1$), the total population under the regular diffusion exceeds the total of the carrying capacity. DeAngelis et al (2016) argued that the prevalence of the population over the carrying capacity is only observed when the growth rate and the carrying capacity are positively correlated, at least for slow dispersal. Guo et al (2020) justified that, once r is constant ($r = K^0$), the total population is less than the cumulative carrying capacity. Together with filling up the gap for when $r = K^\lambda$ for any real λ , we define a diffusion strategy as the tendency to have a distribution proportional to a certain positive prescribed function, once a diffusion coefficient grows infinitely, and explore the interplay of harvesting and dispersal strategies and their influence on the outcome of the competition for two resource-sharing species. While achieving extinction by excessive culling of the undesired species is simple and efficient, keeping biodiversity is a more complicated task. Proposing such heterogeneous harvesting that the two populations become an ideal free pair allows to guarantee coexistence.

Probability of Antibiotic Resistance in Stochastic PK/PD-Based Bacterial Model with Distinct Drug and Mutation Modes

Schedule: July 10 15:30-16:00 Room 432

CAMERON BROWNE

University of Louisiana at Lafayette, USA

Co-Author(s): Chimezie Izuazu

Abstract:

Mathematical models, including differential equations and stochastic processes, have gained considerable attention for understanding the evolution of antibiotic resistance. However, most existing models assume standing genetic variation and do not consider the possibility of random or drug-induced mutation of reference bacterial strains. Therefore, we propose a pharmacokinetics/pharmacodynamics (PK/PD) continuous-time Markov chain considering the competition and mutation between sensitive and resistant bacteria within an infected host during treatment. The proposed model is approximated as a generalized birth-death process with immigration, allowing for explicit derivation of the probability that a resistant population establishes during treatment. In addition to capturing the stochasticity of novel emergence of a resistant bacterial strain, we explore the effects of different antibiotic modes of action, horizontal gene transfer, nutrient availability, and drug pharmacokinetics on antibiotic resistance. We find that replication-targeting (biostatic) drugs suppress resistance more than death-targeting (biocidal) drugs. Like prior works, we obtain maximized resistance at intermediate drug concentrations; however, the consideration of novel mutation magnifies the superiority of higher doses in preventing resistance emergence. Our general approach allows for numerically calculating resistant density distributions and first passage times, which can provide further advances in quantifying the likelihood of multi-drug resistance emergence.

Awareness and compliance in an infectious disease model

Schedule: July 10 11:00-11:30 Room 432

Jacques Bélair

Université de Montréal, Canada

Abstract:

Management of the COVID-19 pandemic required in its early stages the deployment of non pharmaceutical interventions (NPIs) [social isolation, physical distancing, mask-wearing, hand-washing]. We consider a compartmental model of disease propagation in which information is the infection: knowledge of, and compliance with, measures limiting the propagation of an infectious disease (such as non-pharmaceutical interventions (NPIs)) are modeled as dynamic parameters. The population is divided in three classes: unaware individuals, aware but noncompliant and aware and compliant individuals so that the model takes the form, in its simplest form, of the equations
$$\begin{cases} S_0'(t) = \mu - \beta A S_0 - \mu S_0 - S_1(t) = (1-p)\beta S_0 A - \beta S_1 A - \mu S_1 + \gamma(A) A \\ A'(t) = \beta (p S_0 + S_1) A - (\mu + \gamma(A)) A \end{cases}$$
 Conditions for the existence of multiple stable equilibria will be discussed as well as the consequences for the control of the infection.

Some dimension reduction techniques for Leslie matrix models

Schedule: July 10 10:30-11:00 Room 432

Troy Day

Queen's University, Canada

Co-Author(s): Amy Forsythe, Sarah Otto

Abstract:

Leslie matrix projection models have long served as powerful tools for tracking populations and their age structure over time. One of their main appeals is the simplicity that arises from grouping individuals into age classes in which all individuals have the same vital rates. Nevertheless, in natural populations many traits influence survival and reproduction and so real-world age groups are composed of a heterogeneous mix of individuals with different vital rates. This heterogeneity is sometimes accounted for in models by expanding the Leslie matrix to include multiple phenotypic classes within each age category; however, it becomes increasingly difficult to analyze these matrices as the dimension increases. Here, we present 3 theorems about when and how projection matrices for populations structured by both age and phenotypic classes can be collapsed to smaller and more easily evaluated matrices while preserving the general solution of the original model.

A nonlocal advection system for two competing species with resources recovering time

Schedule: July 9 17:00-17:30 Room 432

Yoichi Enatsu

Tokyo University of Science, Japan

Co-Author(s): Ping Zeng, Guanyu Zhou

Abstract:

We investigate the nonlocal advection model for two-species competition, which characterizes cell growth and dispersion phenomena in co-culture experiments. To capture realistic phenomena in biology, we introduce the time delay representing population migration and resources recovering time. We investigate the impact of delays on competitive dynamics and to develop numerical methods that ensure biological feasibility of solutions. Accordingly, we design a positivity-preserving finite volume scheme based on an upwind flux approach, guaranteeing non-negative population densities and discrete conservation properties. We examine the convergence orders of the scheme through the numerical experiments and explore the effects of delays on species competition dynamics.

Bistability between acute and chronic states in a Model of Hepatitis B Virus Dynamics

Schedule: July 10 15:00-15:30 Room 432

Hayriye Gulbudak

University of Louisiana at Lafayette, USA

Co-Author(s): Nazia Afrin, Stanca Ciupe, Jessica Conway

Abstract:

Understanding the mechanisms responsible for different clinical outcomes following hepatitis B infection requires a systems investigation of dynamical interactions between the virus and the immune system. To help elucidate mechanisms of protection, we developed a deterministic mathematical model of hepatitis B infection that accounts for cytotoxic immune responses resulting in infected cell death, non-cytotoxic immune responses resulting in infected cell cure and protective immunity from reinfection, and cell proliferation. We analysed the model and presented outcomes based on three important disease markers: the basic reproduction number $\mathcal{R}_0$, the infected cells death rate δ (describing the effect of cytotoxic immune responses), and the liver carrying capacity K (describing the liver susceptibility to infection). Using asymptotic and bifurcation analysis techniques, we determined regions where virus is cleared, virus persists, and where clearance-persistence is determined by the size of viral inoculum. These results can guide the development of personalized intervention.

The transmission of chikungunya in Guangdong China in 2025

Schedule: July 9 18:30-19:00 Room 432

Daihai He

The Hong Kong Polytechnic University, Hong Kong

Abstract:

The mosquito-borne infection chikungunya hit Guangdong China in 2025. We propose and fit an epidemic model to the chikungunya reported cases from four hit hardest cities in Guangdong. We analyze mosquito surveillance data from Guangzhou. We assume a unified reporting ratio across cities and over time. We reveal huge temporal changes in transmission rate, which might be due to huge changes in reporting effort in Jiangmen and Foshan. We find the infection attack rates are very different across cities. If we instead assume similar level of infection attack rates across cities, then the reporting ratio must be very different between cities. We also analyze the correlations between transmission rates and environmental factors and mosquito data. But given the short time period, these correlations should be taken with caution.

From Viral Kinetics to Epidemic Dynamics: A Unified Multiscale Modeling Framework with Analytical and Agent-Based Approaches

Schedule: July 10 12:00-12:30 Room 432

Byul Nim Kim

Kyung Hee University/Department of Applied Mathematics, Korea

Co-Author(s): Hyosun Lee, Sunmi Lee

Abstract:

We develop a unified multiscale modeling framework that integrates within-host viral kinetics with population-level epidemic dynamics, combining analytical and agent-based approaches. Motivated by SARS-CoV-2 variant evolution, we first construct a mechanistic SEIIRS-renewal model in which infection-age-dependent infectiousness is derived from viral load trajectories through a nonlinear Hill-type mapping. This formulation enables rigorous analytical characterization of epidemic thresholds, including a kernel-based basic reproduction number, Euler--Lotka growth rates, and explicit conditions for backward bifurcation induced by waning immunity and reinfection. To complement this theoretical framework, we develop a multi-scale agent-based model that embeds empirically inferred viral kinetics into network-based transmission dynamics. By mapping individual viral load trajectories to time-varying transmission probabilities, the model captures heterogeneous contact structures and stochastic transmission processes, allowing for realistic simulation of variant-specific epidemic patterns. Our results demonstrate that differences in viral replication and clearance fundamentally reshape epidemic dynamics, even under identical reproduction numbers. Fast-replicating variants generate earlier and sharper epidemic peaks, whereas slower viral dynamics lead to delayed but more prolonged outbreaks. The integration of within-host kinetics further produces heterogeneous transmission patterns and heavy-tailed secondary infection distributions without imposing ad hoc assumptions. Together, the proposed framework establishes a coherent bridge from biological mechanisms to population-level outcomes, providing both analytical insight and computational tools for understanding variant-specific transmission dynamics. This unified multiscale approach offers a flexible foundation for epidemic forecasting, risk assessment, and timing-sensitive intervention design in emerging infectious diseases.

Modeling tumor evolution, resistance and adaptive therapy

Schedule: July 9 18:00-18:30 Room 432

Eunjung Kim

Korea Institute of Science and Technology, Korea

Co-Author(s): Eunjung Kim, Masud M A, Junho Lee

Abstract:

The therapeutic challenge in oncology arises from the intrinsic complexity of the tumor ecosystem, shaped by both intratumoral heterogeneity and dynamic evolutionary processes. This talk presents an integrated framework combining mathematical modeling, biological experiments, and clinical data to dissect these complexities and translate biological insight into clinically actionable strategies. I begin by examining the role of the tumor microenvironment, with a particular focus on cancer-associated fibroblasts (CAFs) and cell-intrinsic signaling heterogeneity. Our studies, spanning from the role of senescent fibroblasts in melanoma initiation to recent ordinary differential equation (ODE) models of CAF heterogeneity, show how both extrinsic and intrinsic factors drive tumor progression and therapeutic resistance. Using spatial simulations, we further investigate how the spatial organization of resistant cells and fibroblasts shapes treatment response, underscoring the importance of spatially explicit modeling in complex tumor systems. Building on this foundation, I then shift from understanding resistance mechanisms to managing them through an evolutionary perspective. I will discuss the development of patient-calibrated mathematical models for predicting responses to adaptive therapy. In contrast to conventional maximum tolerated dose (MTD) strategies, which often promote the expansion of resistant clones, our work focuses on evolutionary dosing and the identification of effective dose windows. These approaches aim to preserve a population of treatment-sensitive cells that can suppress resistant populations through competition, thereby delaying competitive release and prolonging tumor control. Finally, I will highlight ongoing efforts to bridge mathematical theory and clinical translation, including key open questions in adaptive therapy. Collectively, these studies illustrate the power of integrating theoretical, experimental, and clinical approaches to advance a more personalized and evolution-informed cancer treatment strategy.

THE FIRST MATHEMATICAL MODEL FOR ELK-WOLF INTERACTION IN YELLOWSTONE NATIONAL PARK USING E-SINDY ALGORITHM

Schedule: July 10 14:30-15:00 Room 432

Nitu Kumari

IIT Mandi, India

Abstract:

The ecological dynamics between elk and wolves in northern Yellowstone have been a focal point of long-term research, particularly following the reintroduction of wolves to the region. Although numerous studies have explored this prey-predator interaction from ecological and behavioral perspectives, there remains a lack of comprehensive analysis using mathematical modeling approaches capable of uncovering underlying dynamical patterns and system-level insights. In this study, we investigate the prey-predator dynamics of the elk--wolf system in northern Yellowstone National Park, USA, using a data-driven modeling approach. We used yearly population data for elk and wolves from 1995 to 2022 (28 years) to construct a mathematical model using a sparse regression modeling framework. To the best of our knowledge, no previous work has applied this framework to capture elk--wolf interactions over this time period. Our modeling pipeline integrates Gaussian process regression for data smoothing, sparse identification of nonlinear dynamics for model discovery, and model selection techniques to identify the most suitable mathematical representation. The resulting model is analyzed for its non-linear dynamics with ecologically meaningful parameters.

Modeling for a purpose: an influenza outbreak in a boarding school revisited.

Schedule: July 10 8:30-9:00 Room 432

Michael Li

University of Alberta, Canada

Abstract:

Assessment of models should depend on the modeling objectives. Models that incorporate more realistic mechanisms are more suitable for providing insights. To produce reliable and accurate predictions and inform public health decision making, parsimonious models are more appropriate and the modeling needs to respect the data. Most of all, model calibration results should be validated by data that is independent of the calibration data, before scenario analysis is made to inform policy. As a case study, we revisit the well-known example of a 1978 influenza outbreak in a boarding school in England. We demonstrate that a parsimonious SIR model with data informed time-dependent parameters can produce both accurate fitting to the time series data and validation by the final size of the epidemic. Furthermore, modeling results also provide evidence of the likely epidemic control measures implemented at the school.

Infectious disease surveillance using deep learning models

Schedule: July 10 9:30-10:00 Room 432

Bouchra BN NASRI

University of Montreal, Canada

Abstract:

Social media data has become widely used to monitor infectious diseases. This presentation will showcase case studies of social media data related to Mpox and Lyme disease, demonstrating the utility of such data in predicting cases and other disease-related characteristics.

Catastrophic changes in coral reef dynamics under macroalgal toxicity, elevated sea surface temperature (SST), overfishing and invasion of predators

Schedule: July 9 16:30-17:00 Room 432

Samares Pal

University of Kalyani, India

Abstract:

Coral reef ecosystems are most vulnerable to changes in sea surface temperature (SST), a key environmental factor critical to reef-building growth. Elevated SST reduces the ability of corals to produce their calcium carbonate skeletons. Prolonged high SST results in coral bleaching owing to the uncoupling of symbiosis among corals and microalgae. Corals have narrow temperature tolerances. The skeletal growth rate of corals falls sharply to zero even at a slight increase of SST above its temperature tolerance level. Corals are also vulnerable to macroalgal toxicity. Several benthic macroalgae species are known to bring about allelopathic chemical compounds that are very harmful to corals. The toxic-macroalgae produce allelochemicals for which the survivability and settlement of coral larvae are highly affected. Toxic macroalgae species damage coral tissues when in contact by transferring hydrophobic allelochemicals present on macroalgal surfaces, leading to a reduction of corals and even coral mortality. The abundance of toxic macroalgae changes the community structure towards a macroalgae-dominated reef ecosystem.

Modeling Climate-Driven Spatiotemporal Mosquito Population and Dengue Risk

Schedule: July 10 9:00-9:30 Room 432

Naveen K. Vaidya

San Diego State University, USA

Abstract:

Dengue fever is a vector-borne viral disease primarily transmitted by *Aedes* mosquitoes. Both population structure and dengue transmission are highly influenced by climate conditions. In this talk, I will present a dynamical system model and a math-model-informed neural network (MINN) based method to predict climate-driven spatiotemporal dynamics of mosquito populations. Furthermore, I will develop a hybrid probabilistic-mechanistic, data-driven model that enables us to estimate a practical, local-level risk of dengue infection. We use data from Nepal, which provides a valuable setting for dengue modeling due to its strong spatial heterogeneity; its 77 districts span a wide range of elevation and climate zones. We analyze our model to formulate reproduction numbers that determine the global dynamics of mosquito survival. Our method identifies the climate conditions that help control dengue-transmitting mosquitoes. Our results provide critical insights into the role of climate change in shifting the distribution of dengue-transmitting mosquitoes and related epidemics into colder regions. Our model's real-time risk assessment provides an evidence-based methodology for designing public health policies.

Cognitive Movement Strategies in a Resource-Threat Dilemma

Schedule: July 10 14:00-14:30 Room 432

Tianxu Wang

university of Alberta, Canada

Co-Author(s): Jiwoon Sim, Hao Wang

Abstract:

Dilemmas involving trade-offs between acquiring food and avoiding threats are unavoidable in animals' daily lives. To enhance survival, they must continually adjust their movement in response to environmental cues, while internal hunger levels also strongly influence their decision-making processes. In this study, we develop a general coupled PDE--ODE model that integrates movement strategies driven by internal hunger dynamics. Even in the same environment, different species may prioritize different types of information. We investigate how various cognitive movement strategies affect species' survival outcomes in simplified food--threat dilemmas. Specifically, we compare five commonly observed strategies based on local gradients, regional maxima, global maxima, regional aggregate gradients, and global aggregate gradients. We prove the well-posedness of the model, in which a general function of the ODE variable appears in the taxis sensitivity function in the PDE equation, and we conduct a stability analysis around arbitrary equilibria. These results are then used to determine survival and extinction conditions under each strategy. Numerical simulations show that the effectiveness of movement strategies strongly depends on environmental context. The global-maximum strategy yields the greatest survival with minimal foraging and threat-avoidance effort in a simple dilemma, while in more complex multimodal environments, local strategies produce the highest population survival rate.

Modeling and Analysis of Legionnaires' Disease

Schedule: July 9 17:30-18:00 Room 432

Lihong Zhao

Kennesaw State University, USA

Abstract:

Some pathogens can survive and replicate in abiotic environment outside the host systems and rely on the interaction with an environmental reservoir to transmit and infect hosts. Mathematical modeling can provide insights into the complex and often unknown dynamics of environmentally transmitted diseases. One such disease is Legionnaires' disease (LD), an atypical pneumonia caused by the inhalation of the intracellular bacterium *Legionella pneumophila* suspended in aerosolized water. Reported LD cases have been increasing since the early 2000s, with nearly 10,000 LD cases were reported in the United States. LD remains underdiagnosed and underreported; therefore, its true incidence is unknown. In this talk, I will present the models we developed to examine the factors that may have contributed to the increase in LD outbreaks, and the insights into management strategies using control theory.

Special Session 25 : Recent Progress on Mathematical Analysis of PDEs Arising in Fluid Dynamics

Organizer(s): Huanyao Wen , Changjiang Zhu , Huijiang Zhao

Introduction: This session aims to bring together mathematicians to present their recent results in partial differential equations arising in fluid dynamics. In particular it focuses on global existence theory, long-time behaviors, stability and instability, free boundary problems, etc for Navier-Stokes equations (single-fluid flow), two-fluid model and related physical models. Some challenging open problems in these interesting fields are expected to highlight.

The global existence and low Mach number limit for full Navier-Stokes equations around the Couette flow in channels

Schedule: July 9 15:30-16:00 Room 812

Tuowei Chen

School of Mathematics, South China University of Technology, Peoples Rep of China

Co-Author(s): Qiangchang Ju 

Abstract:

This talk is concerned with the two-dimensional full compressible Navier-Stokes equations between two finite or infinite parallel isothermal walls, where the upper wall is moving with a horizontal velocity, while the lower wall is stationary, and there allows a temperature difference between the two walls. It is shown that if the initial state is close to the Couette flow with a temperature gradient, then the global strong solutions exist, provided that the Reynolds and Mach numbers are low and the temperature difference between the two walls is small. The low Mach number limit of the global strong solutions is also shown for the case that both walls maintain the same temperature.

Qualitative and quantitative homogenization of some non-Newtonian flows in perforated domains

Schedule: July 9 14:30-15:00 Room 812

Yong Lyu

Nanjing University, Peoples Rep of China

Co-Author(s): Richard M. Hofer, Florian Oschmann; Zhengmao Qian, Chenchen Zhang

Abstract:

We consider the homogenization of some viscous incompressible non-Newtonian flows in perforated domains. With certain general assumptions on the nonlinear stress tensor, we show the limit system is the Darcy's law for the case of 'small holes', and system remain unchanged for the case of 'large holes'. Quantitative convergence rates are also given for both the velocity field and the pressure.

Convergence of a finite volume method to weak solutions for the compressible Navier-Stokes-Fourier system

Schedule: July 9 15:00-15:30 Room 812

Bangwei She

Capital Normal University, Peoples Rep of China

Co-Author(s): Eduard Feireisl, Maria Luk\`a\`v{c}ov\`a-Medvid\`ov\`a, Yuhuan Yuan

Abstract:

We prove strong convergence of an upwind-type finite volume method to a weak solution of the Navier-Stokes-Fourier system with the Dirichlet boundary conditions. The limit solution satisfies a weak form of the mass and momentum equations, together with a weak form of the entropy and ballistic energy inequalities, and complies with the weak-strong uniqueness principle. The finite volume method uses piecewise-constant spatial approximations. The convergence proof is based on a combination of delicate consistency estimates with a careful analysis of the oscillations of numerical densities via renormalisation of the continuity equation.

Global well-posedness and decay rates of solutions to a P1-approximation model arising from radiation hydrodynamics

Schedule: July 9 17:00-17:30 Room 812

Wenjun Wang

University of Shanghai for Science and Technology, Peoples Rep of China

Abstract:

This talk is concerned with the global existence and large-time behavior of solutions to the Cauchy problem for a P1-approximation radiation hydrodynamics model. The global existence result is established for small perturbations in the Sobolev space around a stable radiative equilibrium state. Moreover, the decay rates of the solution and its derivatives are obtained accordingly.

Global existence and uniqueness of strong solution to compressible Navier-Stokes equations with vacuum

Schedule: July 9 17:30-18:00 Room 812

Huanyao Wen

South China University of Technology, Peoples Rep of China

Abstract:

In this talk, we will introduce our recent progress on global wellposedness of compressible Navier-Stokes equations with vacuum and smallness of initial data satisfying scaling invariance properties in three dimensions.

Hydrodynamic limit for compressible Navier-Stokes-Vlasov equations

Schedule: July 9 16:30-17:00 Room 812

Lei Yao

Northwestern Polytechnical University, Peoples Rep of China

Co-Author(s): Yunfei Su; Lei Yao

Abstract:

We study the hydrodynamic limit of weak solutions to compressible Navier-Stokes-Vlasov equations in one dimension bounded domain. Due to the absence of dissipation terms in particle equation, it is difficult to study this problem. We take advantage of compactness result in one space dimension to obtain the convergence of macroscopic density of the particles in $C([0, T]; H^{-1})$. The proof relies on relative entropy method to obtain the corresponding strong convergence of fluid density. At last, we give a recent result about hydrodynamic limit for multidimensional compressible Navier-Stokes-Vlasov-Poisson equations with local alignment force.

Universality in the Low Mach Number Limit via a Convex Integration Framework

Schedule: July 9 14:00-14:30 Room 812

Cheng Yu

University of Florida, USA

Co-Author(s): Ming Chen, Alexis Vasseur, Dehua Wang

Abstract:

In this talk, I will discuss the low Mach number limit of the compressible Euler equations from the perspective of convex integration. Given any prescribed L^2 weak solution of the incompressible Euler equations, we construct a corresponding family of weak solutions to the compressible system via a refined convex integration scheme. We then show that, as the Mach number tends to zero, this family converges strongly to the prescribed incompressible solution. This is joint work with Ming Chen, Alexis Vasseur, and Dehua Wang.

Special Session 26 : Nonlinear partial differential equations and their applications

Organizer(s): Xiangqing Liu , Yuanze Wu , Fukun Zhao

Introduction: Nonlinear partial differential equations originating from quantum mechanics and divergence-type semilinear partial differential equations arising from incompressible ideal fluid problems are two of the most important partial differential equations, which have been widely and deeply studied in the past forty years, including the existence theory, local and global properties such as existence, uniqueness, regularity, asymptotic behavior, formation of singularities, as well as other special properties of the solutions, via the variational method, Lyapunov-Schmidt reduction method, the concentration compactness principle and other methods in nonlinear functional analysis and partial differential equations. Thus, it is the time to organize the active researchers on these topics together to report their most recent works and discuss the potential directions in these topics.

On some sharp Hardy-Littlewood-Sobolev type inequalities

Schedule: July 7 16:30-17:00 Room 825

Qianqiao Guo

School of Mathematics and Statistics, Northwestern Polytechnical University, Peoples Rep of China

Abstract:

We establish some sharp Hardy-Littlewood-Sobolev type inequalities. For some cases, the extremal functions are classified via the method of moving spheres, and the best constants are computed. This is joint work with Jingbo Dou, Zhe Pu, Jiankang Xia, Xiqiang Zhang and Meijun Zhu.

Eventual monotonicity of the first nonzero Steklov eigenvalue for perimeter-normalized regular N-gons

Schedule: July 7 17:00-17:30 Room 825

Yeyao Hu

Central South University, Peoples Rep of China

Co-Author(s): Zhuo Cheng, Changfeng Gui, Qinfeng Li, Ruofei Yao

Abstract:

In this talk, we show that the first nonzero Steklov eigenvalue of the regular N-gon with fixed perimeter is strictly increasing as N increases, provided that N is sufficiently large; for instance, this holds for N greater than or equal to 20. The talk is based on joint work with Zhuo Cheng (CSU), Changfeng Gui (University of Macau), Qinfeng Li (HNU), and Ruofei Yao (SCUT).

Uniqueness results for the planar Dirichlet Lane-Emden problem

Schedule: July 7 14:00-14:30 Room 825

Isabella Ianni

Sapienza University, Italy

Co-Author(s): De Marchis, Grossi, Luo, Pacella, Yan

Abstract:

We present uniqueness results for non-negative solutions of semilinear equations with a power nonlinearity, set in bounded planar domains with Dirichlet boundary conditions. The talk is mainly based on the following joint works: [1] F. De Marchis, M. Grossi, I. Ianni, F. Pacella, Morse index and uniqueness of positive solutions of the Lane-Emden problem in planar domains, J. Math. Pures Appl. 128, 2019. [2] M. Grossi, I. Ianni, P. Luo, S. Yan, Non-degeneracy and local uniqueness of positive solutions to the Lane-Emden problem in dimension two, J. Math. Pures Appl. 128, 2022. [3] I. Ianni, P. Luo, S. Yan, Morse index, topological degree and local uniqueness of multi-spikes solutions to the Lane-Emden problem in dimension two, submitted

On the bifurcation diagram for free boundary problems arising in plasma physics

Schedule: July 7 15:30-16:00 Room 825

Aleks Jevnikar

University of Udine, Italy

Co-Author(s): D. Bartolucci, J. Wei, R. Wu

Abstract:

We are concerned with qualitative properties of the bifurcation diagram of a free boundary problem arising in plasma physics, showing in particular uniqueness and monotonicity of its solutions. We then discuss a new approach to study the Rabinowitz continuum of classical Gelfand problems.

Existence of positive solutions for a class of almost critical problems on an annulus

Schedule: July 7 15:00-15:30 Room 825

Gabriele Mancini

University of Bari Aldo Moro, Italy

Co-Author(s): Giuseppe Rago, Giusi Vaira

Abstract:

In this talk I will give a brief overview of some results concerning the existence of positive multi-peak solutions with Dirichlet boundary conditions for a class of slightly subcritical or slightly supercritical elliptic problems. I will also present some recent results, obtained in collaboration with Giuseppe Rago and Giusi Vaira, on arbitrary dimensional annuli. By exploiting the explicit form of the Green function and the Robin function for the annulus, we prove that, in the slightly subcritical case, the annulus must become thinner and thinner as the number of peaks increases, whereas, in the slightly supercritical case, the inner hole of the annulus must be very small.

The nonlinear p-curl-curl problem

Schedule: July 7 13:30-14:00 Room 825

Jaroslav Mederski

Institute of Mathematics, Polish Academy of Sciences, Poland

Co-Author(s): Jarosław Mederski and Andrzej Szulkin

Abstract:

Nonlinear curl-curl problems have recently emerged in the study of exact electromagnetic wave propagation in nonlinear media modeled by Maxwell's equations. In particular, the quintic effect gives rise to a critical partial differential equation involving the curl-curl operator. Ground state solutions of this problem are closely related to the optimizers of a new Sobolev-type inequality. In this work, we present recent results on the existence of ground state solutions and discuss certain symmetry properties of the problem. Applications to zero modes of the Dirac equations are also considered. This is joint work with Andrzej Szulkin.

Multiple nodal solutions of Kirchhoff-Choquard equations with logarithmic potential and critical exponential nonlinearity

Schedule: July 7 14:30-15:00 Room 825

Olimpio Miyagaki

UFSCAR, Brazil

Co-Author(s): E. Boer, E. Barboza, O.H. Miyagaki and C. Santana

Abstract:

In this work, we study a class of planar Kirchhoff-Choquard equations involving a sign-changing logarithmic kernel and an exponential nonlinearity. Our main goal is to construct solutions with k nodes for any given $k \in \mathbb{N}$, thereby establishing the multiplicity of solutions for this class of problems. To achieve this, we employ a gluing method inspired by the framework developed in [T. Bartsch, M. Willem-ARMA 1993, and, D. Cao, X. Zhu- Acta Math. Sci. 1998]. The analysis presents substantial challenges due to the interaction among the nonlocal Kirchhoff term, the sign-changing nature of the Choquard kernel, and the lack of compactness induced by the exponential nonlinearity, which is critical in two-dimensional settings. Overcoming these difficulties requires a careful and refined analytical approach to successfully implement the gluing construction.

Special Session 29 : Stochastic Dynamical Systems

Organizer(s): Lin Shi , Jun Shen

Introduction: Stochastic dynamical systems (SDS) provide a powerful framework for understanding the interplay between randomness and deterministic dynamics in complex systems. This special session aims to bring together researchers working on theoretical, numerical, and applied aspects of SDS to explore recent advancements and emerging challenges in the field. Topics of interest include but are not limited to: invariant manifolds, stochastic bifurcations, invariant measures, ergodic theory, random attractors, and applications in climate science, biology, and engineering. The session will foster interdisciplinary discussions, highlighting novel methodologies and their implications for modeling and predicting systems subject to random perturbations. Contributions from both established experts and early-career researchers are encouraged to promote a diverse and dynamic exchange of ideas.

A mild rough Gronwall Lemma with applications to non-autonomous evolution equations

Schedule: July 6 13:30-14:00 Room 638

Alexandra Blessing

University of Konstanz, Germany

Co-Author(s): Mazyar Ghani Varzaneh, Tim Seitz

Abstract:

We derive a Gronwall type inequality for mild solutions of non-autonomous parabolic rough partial differential equations (RPDEs). This inequality together with an analysis of the Cameron-Martin space associated to the noise, allows us to obtain the existence of moments of all order for the solution of the corresponding RPDE and its Jacobian when the random input is given by a Gaussian Volterra process. Applying further the multiplicative ergodic theorem, these integrable bounds entail the existence of Lyapunov exponents for RPDEs. We illustrate these results for stochastic partial differential equations with multiplicative boundary noise.

Most Probable Paths for McKean--Vlasov Systems: Deriving the Onsager--Machlup Functional via Euler-Type Classical SDEs

Schedule: July 6 14:00-14:30 Room 638

Ying Chao

Xi'an Jiaotong University, Peoples Rep of China

Abstract:

The Onsager--Machlup functional is fundamental in characterizing fluctuations in nonequilibrium systems. For McKean--Vlasov stochastic differential equations, its derivation is challenging due to the distribution dependence in both drift and diffusion terms. In this talk, we introduce an Euler-type approximation scheme based on classical (distribution-independent) stochastic differential equations, each admitting an explicit Onsager--Machlup functional. By proving convergence to the McKean--Vlasov system, we rigorously obtain the corresponding functional in closed form. This constructive approach extends naturally to a broad class of distribution-dependent stochastic systems.

Random Attractors for McKean-Vlasov SDEs

Schedule: July 6 14:30-15:00 Room 638

Mengyu Cheng

Dalian University of Technology, Peoples Rep of China

Abstract:

In this talk, we focus on the existence of random attractors for McKean-Vlasov SDEs on a separable Hilbert space H . A significant challenge arises from the distribution-dependence of the coefficients, causing the lack of the stochastic flow property on H . To address this, we first transform the original equation into a system on the product space $H \times \mathcal{P}(H)$ and consider the existence of random attractors on this space. We then analyze cocycles associated with two parametric dynamical systems, define the corresponding pullback random attractor, and develop a general theory for the existence of random attractors for such cocycles. Finally, we apply our theoretical results to McKean-Vlasov stochastic ordinary differential equations, McKean-Vlasov stochastic reaction-diffusion equations, and McKean-Vlasov stochastic 2D Navier-Stokes equations. When the attractor reduces to a singleton $\mathcal{A}(\omega) := (\xi(\omega), \mu_\infty)$, we show ξ is the stationary solution for the decoupled stochastic partial differential equation, satisfying $\mathbb{P} \circ [\xi]^{-1} = \mu_\infty$. This talk is based on a joint work with Xianjin Cheng and Zhenxin Liu.

Amplitude Equations for SPDEs

Schedule: July 6 15:00-15:30 Room 638

Hongjun Gao

Southeast University, Peoples Rep of China

Abstract:

In this talk, we consider a class of stochastic partial differential equations (SPDEs) subject to a small deterministic perturbation that measures the distance to the change of stability, as well as a small random perturbation. Using multi-scale analysis, we derive amplitude equations for such SPDEs and then employ them to construct approximate solutions. We focus on the cases where the noise is given by standard Brownian motion or fractional Brownian motion.

Large Deviations for Multiscale McKean-Vlasov Systems Driven by Fractional Brownian Motion

Schedule: July 6 15:30-16:00 Room 638

Jingyue Gao

Southeast University, Peoples Rep of China

Co-Author(s): Jingyue Gao; Hongjun Gao

Abstract:

This work investigates the asymptotic behavior of multiscale McKean-Vlasov stochastic differential equations. The system consists of a slow component perturbed by a small fractional Brownian motion with Hurst index $H \in (1/2, 1)$ and a fast component driven by an independent standard Brownian motion. We establish the large deviation principle to characterize the probability of deviations from the averaged process. The main results are established via a weak convergence approach combined with the occupation measure method. The main challenge lies in addressing the inherent interplay between the distribution-dependent coefficients and the memory effects inherent in the fractional noise.

Random dynamical systems for McKean-Vlasov SDEs via rough path theory

Schedule: July 6 16:30-17:00 Room 638

Shanshan Hu

TU Berlin, Germany

Abstract:

The existence of random dynamical systems for McKean--Vlasov SDEs is established. This is approached by considering the joint dynamics of the corresponding nonlinear Fokker-Planck equation governing the law of the system and the underlying stochastic differential equation (SDE) as a dynamical system on the product space $\mathbb{R}^d \times \mathcal{P}(\mathbb{R}^d)$. The proof relies on two main ingredients: At the level of the SDE, a pathwise rough path-based solution theory for SDEs with time-dependent coefficients is implemented, while at the level of the PDE a well-posedness theory is developed, for measurable solutions and allowing for degenerate diffusion coefficients. The results apply in particular to the so-called ensemble Kalman sampler (EKS), proving the existence of an associated RDS under some assumptions on the posterior, as well as to the Lagrangian formulation of the Landau equation with Maxwell molecules. As a by-product of the main results, the uniqueness of solutions to non-linear Fokker--Planck equations associated to the EKS is shown.

Local First Integrals and Poincaré-Type Nonintegrability for SDEs

Schedule: July 6 17:00-17:30 Room 638

Kaiyin Huang

Sichuan University, Peoples Rep of China

Abstract:

This talk studies local first integrals for stochastic differential equations (SDEs). We define strong and weak local first integrals, and present necessary conditions for the existence of analytic first integrals by using resonance relations. The classical Poincaré nonintegrability theorem is extended to the stochastic framework.

A new branching diffusion solver for reaction-diffusion equations

Schedule: July 6 17:30-18:00 Room 638

Qiao Huang

Southeast University, Peoples Rep of China

Co-Author(s): Nicolas Privault

Abstract:

Stochastic branching algorithms provide a useful alternative to grid-based schemes for the numerical solution of partial differential equations, particularly in high-dimensional settings. However, they require a strict control of the integrability of random functionals of branching processes in order to ensure the non-explosion of solutions. In this paper, we study the stability of a functional branching representation of PDE solutions by deriving sufficient criteria for the integrability of the multiplicative weighted progeny of stochastic branching processes. We also prove the uniqueness of mild solutions under uniform integrability assumptions on random functionals. This talk is based on joint work with N. Privault.

Inertial Manifolds Without Spectral Gap Conditions: Modified Navier-Stokes Equations

Schedule: July 6 18:00-18:30 Room 638

Xinhua Li

School of Mathematics and Statistics, Lanzhou University, Peoples Rep of China

Co-Author(s): Chunyou Sun

Abstract:

Inertial manifold (IM) is a finite-dimensional invariant manifold that contains the global attractor and that attracts all the orbits at an exponential rate, and it is also a graph of some Lipschitz continuous functions. If a PDE possesses an IM, then its dynamical can be completely determined by a system of ODEs. Classical theory of IM required a so-called spectral gap condition for constructing an IM. In this talk, we introduce the method of spatial averaging which can construct IMs without spectral gap condition and consider the application for 2D modified Navier-Stokes equations (NSEs). An original motivation for the theory of IMs was treating the NSEs. Unfortunately, this problem is still open now. This talk will review key results concerning IMs for modified NSEs and present our recent contributions to this topic.

Dynamical order in noisy oscillators under unidirectional coupling on a line

Schedule: July 6 18:30-19:00 Room 638

Xiaofang Lin

University of science and technology of China, Peoples Rep of China

Co-Author(s): Bochun Chang; Yi Wang

Abstract:

Dynamical order refers to the property that the global random attractor is a conal curve. It is established herein for noisy oscillator under unidirectional strong coupling on a line. The existence of one-dimensional global random attractor is obtained by identifying it as a manifold via stable foliation theory. We introduce the concept of random differentially positive systems to analyze its order structure. A key difficulty is that the evolution of a conal curve need not converge in general. To address this, we construct a suitably designed cone field that ensures uniform control over the growth of the evolution. By analyzing the evolution of a special conal curve, we prove that its evolution admits a sequential limit in the C^0 -topology and that the global random attractor coincides with the limit, which is itself a closed conal curve, thereby establishing the dynamical order.

Limit Theorems for Inhomogeneous Markov Processes with Applications to SPDEs

Schedule: July 7 8:00-8:30 Room 638

Rongchang Liu

Sichuan University, Peoples Rep of China

Co-Author(s): Kening Lu; Bixiang Wang

Abstract:

In this talk, we present recent progress on limit theorems for time-inhomogeneous Markov processes, including the strong law of large numbers, the central limit theorem, and both the Donsker-Varadhan and Freidlin-Wentzell large deviation principles. We assume that the time inhomogeneity is driven by a uniquely ergodic dynamical system and discuss applications to SPDEs.

Local stable and unstable sets for random dynamical systems

Schedule: July 7 8:30-9:00 Room 638

Xue Liu

Southeast University, Peoples Rep of China

Co-Author(s): Xiao Ma and Xiaomin Zhou

Abstract:

In this talk, we study local stable and unstable sets for two-sided continuous bundle random dynamical systems with positive entropy, which serves as natural substitutes for invariant manifolds when $C^{1+\alpha}$ smoothness of the system is unavailable. For uniformly equicontinuous systems and ergodic invariant measures with positive entropy, we prove a lower bound for the Hausdorff dimension of local unstable sets in terms of the ratio of entropy to the maximal Lyapunov exponent. A symmetric statement for local stable sets is obtained by considering the reversed dynamics. Our results apply, in particular, to random dynamical systems generated by random differential equations with globally Lipschitz nonlinearities and to discrete-time systems arising from i.i.d. compositions of homeomorphisms drawn from a precompact subset of $C(X, X)$, where X is a compact metric space. This is a joint work with Xiao Ma and Xiaomin Zhou.

An abstract criterion on the existence and global stability of stationary solutions for random dynamical systems and its applications

Schedule: July 7 9:00-9:30 Room 638

Xiang Lyu

Shanghai Normal University, Peoples Rep of China

Abstract:

We prove a concise and easily verifiable criterion on the existence and global stability of stationary solutions for random dynamical systems (RDSs), which is very useful in a wide range of applications.

A Parameterization Method for Quasi-Periodic Systems with Noise: Computation of Random Invariant Tori

Schedule: July 7 9:30-10:00 Room 638

Pingyuan Wei

Southeast University, Peoples Rep of China

Co-Author(s): Lei Zhang

Abstract:

In this talk, we focus on the study of normally hyperbolic invariant manifolds (NHIMs) for a class of quasi-periodically forced systems subject to additional stochastic noise. These systems can be interpreted as skew-product systems. The existence of NHIMs is established through the development of a parameterization method in the random setting, together with an application of the implicit function theorem in suitable Banach spaces. Based on this framework, we propose algorithms for computing the statistics of NHIMs as well as Lyapunov exponents. This talk is based on joint work with L. Zhang (DUT).

Special Session 30 : Evolution Equations, their Control and Applications

Organizer(s): Shengda Zeng , Stanislaw Migorski

Introduction: The session will explore recent advancements in the study of evolution problems, including their mathematical analysis, optimal control, and practical applications. The emphasis will be on the theory and modeling of issues leading to partial differential equations, examining the well-posedness and characteristics of their solutions, control and optimization, numerical analysis, and their relevance in mechanics and physics. Topics of interest include, but are not limited to, dynamical systems, fixed points, nonconvex and nonsmooth analysis, nonlinear inclusions, and numerical methods. The session invites contributions focused on the theoretical development of optimal controls, their computational challenges, and their applications across various fields in the physical sciences.

Mathematical analysis of a nonlinear contact problem for a viscoelastic rod

Schedule: July 7 8:00-8:30 Room 620

Krzysztof Bartosz

Jagiellonian University, Poland

Abstract:

We consider a nonlinear viscoelastic rod that is in contact with a foundation along its length and with an obstacle at its end. The rod is subjected to body forces and, as a result, its mechanical state evolves. We assume that the internal stress at the end of the rod depends on both its displacement and velocity, and that this relationship takes the form of a Clarke subdifferential inclusion. In a specific case, it coincides with the so-called damped normal compliance condition introduced recently in contact mechanics. This generalizes our previous model, in which the stress depends only on the velocity. Our aim is twofold. The first is to construct an appropriate mathematical model that describes the evolution of the rod. The second is to prove the existence of a weak solution to the problem. To this end, we use a time discretization method for second-order inclusion with multivalued pseudomonotone operators, which constitutes the weak formulation of the problem.

Nonlinear impulsive evolution inclusions with history-dependent operators

Schedule: July 7 8:30-9:00 Room 620

Anna Ochal

Jagiellonian University in Krakow, Poland

Abstract:

In this talk, we present recent advancements in the mathematical analysis and control of nonlinear impulsive evolution inclusions formulated within the framework of an evolution triple of spaces. Our research focuses on a class of variational-hemivariational inequalities involving both convex and nonconvex potentials, as well as history-dependent operators. These systems represent a novel integration of impulsive effects - which introduce discontinuities and state jumps - with nonsmooth potentials described by the Clarke generalized gradient. Using tools from nonsmooth and nonconvex analysis, specifically the Clarke generalized gradient, we establish the existence of solutions to these impulsive systems. A significant part of the presentation is devoted to an optimal control problem, where we prove the existence of optimal control-state triples under general hypotheses on the cost functional and control sets. Furthermore, we illustrate the theoretical results with applications to physical models, such as semipermeability problems and frictional contact, where surface traction is governed by impulsive differential equations. This work highlights the synergy between nonsmooth analysis, impulsive dynamics, and memory effects in solving complex problems in mechanics and physical sciences.

Hemivariational inequality with state-dependent delay

Schedule: July 7 9:00-9:30 Room 620

Shashank Pandey

IIT Roorkee, India

Co-Author(s): Dwijendra N. Pandey

Abstract:

We develop a new class of hemivariational inequality that explicitly accounts for state-dependent memory. Our analysis establishes the existence and approximate controllability of mild solutions by recasting the problem as a differential inclusion. To demonstrate scope, we conclude with a heat equation featuring distributed memory that meets the hypotheses of our main results.

Special Session 31 : Data-Driven Modeling and Control of Complex Systems

Organizer(s): Qunxi Zhu , Siyang Leng , Peijie Zhou

Introduction: Complex systems manifest pervasively across diverse real-world scenarios spanning microscopic to macroscopic scales. Current research is undergoing a paradigm shift from conventional mechanism-based analysis to data-driven modeling methodologies. This endeavor necessitates developing efficient data-driven dynamical models and computational frameworks leveraging massive or limited time-series data, which demands breakthroughs in overcoming traditional algorithms' scalability limitations while preserving their capacity for characterizing nonlinear system features. By revealing intrinsic system architectures and dynamic principles, such advancements will enhance simulation fidelity and prediction accuracy of evolutionary behaviors, achieve intelligent regulation, and ultimately facilitate accelerated progress in complex systems research.

Dynamical Phase Transitions in Nonequilibrium Networks

Schedule: July 6 13:30-14:00 Room 639

Jiazhen Liu

Fudan University, Peoples Rep of China

Abstract:

Dynamical phase transitions (DPTs) characterize critical changes in system behavior occurring at finite times, providing a lens to study nonequilibrium phenomena beyond conventional equilibrium physics. While extensively studied in quantum systems, DPTs have remained largely unexplored in classical settings. Recent experiments on complex systems, from social networks to financial markets, have revealed abrupt dynamical changes analogous to quantum DPTs, motivating the search for a theoretical understanding. Here, we present a minimal model for nonequilibrium networks, demonstrating that nonlinear interactions among network edges naturally give rise to DPTs. Specifically, we show that network degree diverges at a finite critical time, following a universal hyperbolic scaling, consistent with empirical observations. Our analytical results predict that key network properties, including degree distributions and clustering coefficients, exhibit critical scaling as criticality approaches. These findings establish a theoretical foundation for understanding emergent nonequilibrium criticality across diverse complex systems.

High-dimensional Density Estimation

Schedule: July 6 14:00-14:30 Room 639

Lirong Qu

School of Mathematical Sciences, Beijing Normal University, Peoples Rep of China

Abstract:

With the aim of inferring probability density functions from limited observed samples, density estimation via discrepancy based sequential partition (DSP) has been proposed to learn an adaptive piecewise constant approximation defined on a binary sequential partition of the underlying domain, where the star discrepancy is adopted to measure the uniformity of particle distribution. However, the calculation of the star discrepancy is NP-hard. We use heuristic algorithms such as SA, TA, and PT to accelerate the computation of the star discrepancy, and find that TA exhibits the best convergence speed. Furthermore, star discrepancy does not satisfy the reflection invariance and rotation invariance either. To this end, we use the mixture discrepancy and the comparison of moments as a replacement of the star discrepancy, leading to the density estimation via mixture discrepancy based sequential partition (DSP-mix) and density estimation via moments based sequential partition (MSP), respectively. Both DSP-mix and MSP are computationally tractable and exhibit the reflection and rotation invariance. Numerical experiments in reconstructing the d -D mixture of Gaussians and Betas with $d = 2 - 30$ demonstrate that both DSP-mix and MSP run approximately ten times faster than DSP while maintaining the same accuracy.

Modeling environmental feedback in opinion dynamics: Pattern formation and phase transitions

Schedule: July 6 14:30-15:00 Room 639

Rui Wang

School of Mathematical Sciences, Beijing Normal University, Peoples Rep of China

Abstract:

The public opinions in modern information environments are shaped by the interplay between social conformity and environmental exposure. Interactions among individuals promote opinion alignment, while environmental heterogeneity and selective information exposure may reinforce the alignments with their own interests, known as the information cocoon. This work aims at a mathematical description of the underlying mechanisms by combining the opinion dynamics and bounded-confidence interactions with environmentally biased movement. Starting from the particle-level Hegselmann-Krause model and random movements of agents biased by the environment, a nonlocal PDE system under the mean-field scaling is derived, where opinion transport is driven by consensus dynamics and modulated by an attention-dependent cross-diffusion mechanism. The stability of spatially homogeneous states is analyzed, and the threshold conditions that characterize the phase transition between dispersed and aggregated opinion distributions are proposed. The theoretical results are supported by our numerical results produced by a structure-preserving third-order numerical scheme. Moreover, it demonstrates that the formation of spatial opinion clusters enhances the group consensus, and the environmental information flow may modify the timing and the pathway through which consensus is triggered. These observations provide a quantitative framework for understanding how social conformity and environmental exposure jointly shape the organization of public opinion.

Predicting first-order phase transitions in coupled oscillator systems with machine learning

Schedule: July 6 15:00-15:30 Room 639

Zhonghua Zhang

Northwestern polytechnical university, Peoples Rep of China

Co-Author(s): Liang Wang, Stefano Boccaletti, Ludovico Minati, Wei Xu

Abstract:

First-order phase transitions such as explosive death can cause abrupt and irreversible suppression of collective oscillations, making their critical prediction important for preventing dynamical collapse in complex systems. In this talk, I will present two recent machine-learning approaches for predicting such transitions from oscillatory data alone. For low-dimensional coupled oscillators, we adopt a parameter-aware next-generation reservoir computing framework that embeds control parameters into nonlinear feature construction and enables accurate identification of critical points, hysteresis, and bifurcation structures in unseen regimes. For oscillator networks, we further introduce a parameter-aware parallel reservoir computing framework, where node-wise reservoirs preserve scalability while retaining sensitivity to parameter variations. The method accurately predicts explosive amplitude death and oscillation death in networks with different topologies, including nearest-neighbor ring, small-world, and random regular networks, while also reconstructing the corresponding spatiotemporal dynamics. Together, these results provide an efficient and scalable data-driven paradigm for forecasting first-order phase transitions in nonlinear dynamical systems and complex networks.

Special Session 32 : Inverse Problems and Image Processing

Organizer(s): Qiyu Jin , Shengzhu Shi , Taofeng Xie

Introduction: Inverse problems are fundamental in applied mathematics and imaging sciences, playing a crucial role in medical imaging, remote sensing, and computational photography. This session aims to discuss recent advancements in the theory, numerical methods, and applications of inverse problems in image processing. Key topics include regularization techniques, variational models, optimization strategies, and machine learning-based approaches. Special attention will be given to structure-preserving methods that ensure stability, sparsity, and energy conservation. High-order numerical methods and hybrid model-driven and data-driven techniques are essential for solving complex inverse problems. This session will bring together researchers from various fields to present new developments, address challenges, and explore real-world applications such as MRI and CT reconstruction, blind deblurring, and super-resolution. The session aims to provide a platform for interdisciplinary collaboration and innovation in inverse problems and imaging. The topics will span a wide range from theoretical results to novel algorithms, and to a variety of interesting application areas. The workshop will provide a platform for applied mathematicians and application scientists to interact, communicate and foster collaborations.

AFIRE: Accurate and Fast Image Reconstruction Algorithm for Geometric-Inconsistent Multispectral CT

Schedule: July 6 18:00-18:30 Room 636

Chong Chen

Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Yu Gao

Abstract:

Multispectral computed tomography (MSCT) has attracted increasing attention and research interest due to the development of hardware and requirement of applications, as well as its advantages in considering the X-ray energy-dependent information over the conventional CT such as artifact suppression, contrast improvement and object separation. However, accurate and fast image reconstruction in MSCT remains a challenging task, largely because its data model is nonlinear, and the scanning geometry parameters under different X-ray energy spectra are sometimes inconsistent or mismatched. In this talk, we will discuss our recent advances on algorithm and theory for the image reconstruction in geometric-inconsistent MSCT.

An efficient augmented Lagrangian method for dynamic optimal transport based on second-order cone programming

Schedule: July 8 15:30-16:00 Room 442

Liang Chen

Hunan University, Peoples Rep of China

Co-Author(s): Youyicun Lin, Yuxuan Zhou

Abstract:

This talk introduces an efficient numerical approach to solve dynamic optimal transport (DOT) problems with quadratic cost in Euclidean spaces or on surfaces, computing both the quadratic Wasserstein distance and the associated displacement interpolation. Building on the convex DOT model of Benamou and Brenier, we reformulate the discretized dual DOT problem to a linear second-order cone programming (SOCP) problem. Then, by taking advantage of the SOCP reformulation, we can solve them efficiently by a computationally highly economical implementation of an inexact symmetric Gauss-Seidel decomposition-based proximal augmented Lagrangian method, which converges to a Karush-Kuhn-Tucker solution without any additional assumptions. Implemented as open-source software packages, the proposed approach demonstrates robustness, effectiveness, and superior computational efficiency in extensive numerical experiments on various datasets, achieving a several-fold speed-up over the state-of-the-art solvers. Additionally, it exhibits robustness to problems with densities that lack a positive lower bound.

Physics-Driven Deep Learning for CT Metal Artifact Reduction

Schedule: July 8 14:00-14:30 Room 442

Zhangling Chen

Tianjin Normal University, Peoples Rep of China

Abstract:

This report will introduce two types of CT metal artifact reduction (MAR) methods based on the fusion of physical priors and deep learning. The first is a deep unrolling framework with soft metal trace, which adopts an adaptive projection-domain weighting mechanism to preserve effective tissue information and integrates a physics-informed primal dual hybrid gradient optimization scheme into the network to enhance model interpretability. The second is a self-supervised framework based on implicit neural representation, which does not require paired data, combines multi-resolution hash encoding to capture high-frequency anatomical information, and incorporates physical correction operators and an adaptive bone region weighting strategy to achieve simultaneous correction of metal and bone regions.

Segmenting Objects with Imbalanced Sizes via Smooth and Sparse Dual Optimal Transport

Schedule: July 6 17:00-17:30 Room 636

LI CUI

School of Mathematical Science, Beijing Normal University, Peoples Rep of China

Co-Author(s): Mengqi Ding, Gangxuan Zhou, Xue-Cheng Tai, Li Cui, Jun Liu

Abstract:

To address imbalanced object sizes in image segmentation, this work formulates the problem via optimal transport theory and a Laguerre cell decomposition. The dual variable of the volume constraint is interpreted as a learnable bias, and an iterative network-embedding layer (VP-Sparsemax) is proposed to solve the smooth semi-dual formulation while incorporating spatial information. Compared to softmax, VP-Sparsemax improves volume preservation after argmax due to its sparsity. Experiments on four dataset across three segmentation baselines demonstrate superior performance, especially for small targets that are easily overlooked.

NCHG-Seg: Nerve-Prioritized Multi-Scale Tissue Segmentation and Nerve-Centric Heterogeneous Graph Learning for Perineural Invasion Modeling and Survival Prediction in Pancreatic Cancer

Schedule: July 6 15:00-15:30 Room 636

Luying Gui

Nanjing University of Science and Technology, Peoples Rep of China

Co-Author(s): Ma Rukang; Han Wennan; Wang Bingxue

Abstract:

Perineural invasion (PNI) is a pivotal prognostic indicator in pancreatic cancer, yet accurate quantification is hindered by subjective assessment and imprecise tissue segmentation. We propose NCHG-Seg, an integrated framework that introduces a nerve-prioritized multi-scale segmentation module and a nerve-centric heterogeneous graph (NCHG) for precise tumor-nerve interaction modeling. The segmentation augments a Swin Transformer with nerve-prior attention and boundary-aware refinement, yielding high-fidelity nerve, tumor, and microenvironment masks from gigapixel WSIs. These masks enable hierarchical graph construction with intra-tumoral nodes defined by geometric containment and boundary proximity, followed by a biologically inspired dual-attention message-passing mechanism (Structural Attention and Feature Similarity Attention). Experiments across three multicenter cohorts (TCGA-PAAD, GULOU, SZY) show that NCHG-Seg achieves a C-index of 0.6437 and AUC of 0.6857 on TCGA-PAAD, outperforming state-of-the-art WSI-based survival models with strong cross-center generalization. Our approach offers an interpretable tool for quantitative PNI assessment in precision oncology.

Mixed geometry information regularization for image deblurring with multiplicative noise

Schedule: July 6 17:30-18:00 Room 636

Zhichang Guo

Harbin Institute of Technology, Peoples Rep of China

Abstract:

We propose a variational model for the simultaneous removal of multiplicative noise and blur. Variational regularization techniques have been widely employed in various image processing tasks. However, designing models that incorporate sufficient geometric priors remains a challenging problem. To address this issue, we introduce a mixed geometry regularization that integrates both area and curvature terms as priors. Due to the high-order and nonlinear nature of the model, minimizing the associated functional is nontrivial. To overcome this challenge, we adopt the additive operator splitting method and a relaxed scalar auxiliary variable (RSAV) approach, with the latter showing higher computational accuracy for our model. The unconditional stability of these algorithms allows the use of a large time step. Furthermore, we discuss several theoretical properties of the RSAV method. Numerical experiments demonstrate the effectiveness of the proposed model and the efficiency of the corresponding algorithm. Extensive results indicate that our model can effectively address both image deblurring and multiplicative noise removal simultaneously.

Variational Framework for Image Vectorization and Applications

Schedule: July 7 8:30-9:00 Room 442

Roy Yuchen He

City University of Hong Kong, Hong Kong

Abstract:

Images are commonly represented as bitmaps, making it essential to identify the intrinsic geometric features of objects from such unstructured data. Vectorization is a widely used technique that converts raster images into collections of parametric curves and surfaces, capturing the input's prominent features while yielding resolution-independent representations. In this talk, we propose variational principles for image vectorization, together with efficient algorithms based on the affine shortening flow and region merging, generalizing steepest gradient descent for the reduced Mumford-Shah functional. We also present recent applications in shape classification and historical glyph preservation.

Quadratic convergence of the Gauss-Newton method for complex phase retrieval

Schedule: July 6 15:30-16:00 Room 636

Meng Huang

Beihang University, Peoples Rep of China

Abstract:

We introduce a Gauss-Newton method for solving the complex phase retrieval problem. In contrast to the real-valued setting, the Gauss-Newton matrix for complex-valued signals is rank-deficient and, thus, non-invertible. To address this, we utilize a Gauss-Newton step that moves orthogonally to certain trivial directions. We establish that this modified Gauss-Newton step has a closed-form solution, which corresponds precisely to the minimal-norm solution of the associated least squares problem. Additionally, using the leave-one-out technique, we demonstrate that $m \geq O(n \log^3 n)$ independent complex Gaussian random measurements ensures that the entire trajectory of the Gauss-Newton iterations remains confined within a specific region of incoherence and contraction with high probability. This finding allows us to establish the quadratic convergence rate of the Gauss-Newton method without the need of sample splitting.

A Gaussian Mixture-Based Sequential Monte Carlo Algorithm for Solving Infinite-Dimensional Statistical Inverse Problems

Schedule: July 7 9:30-10:00 Room 442

Junxiong Jia

Xi'an Jiaotong University, Peoples Rep of China

Co-Author(s): Haoyu Lu

Abstract:

In this talk, we introduce a sequential Monte Carlo (SMC-GM) algorithm equipped with a Gaussian mixture transition kernel. This algorithm is designed to improve the efficiency of sampling from the posterior measure in infinite-dimensional Bayesian inverse problems. We establish the denseness of Gaussian mixture measures with respect to the total variation distance in separable Hilbert spaces, which serves as the foundation for our convergence theory. Additionally, we propose a well-defined preconditioned Crank-Nicolson method with a Gaussian mixture prior (pCN-GM) for use in infinite-dimensional function spaces. By leveraging the denseness of Gaussian mixture measures and the invariance of the pCN-GM transition kernel, we provide a convergence theorem for SMC-GM. In our numerical experiments, we apply this method to a nonlinear Darcy flow statistical inverse problem, confirming its high sampling efficiency, low error, capability to sample complex posteriors, and dimension-independence.

Image Inverse Problems with Generative Priors

Schedule: July 8 13:30-14:00 Room 442

Ji Li

Capital Normal University, Peoples Rep of China

Co-Author(s): Ji Li

Abstract:

The design of image prior representations is pivotal to solving image inverse problems. With the recent rapid development of deep learning, image priors have evolved from traditional expert-designed and data-driven representations to those learned via generative models. More precise image priors undoubtedly lead to enhanced performance in computational imaging tasks. This talk first provides a brief introduction to the paradigm of learning data distributions using Ordinary Differential Equation (ODE)-controlled generative models. Subsequently, we discuss two perspectives on applying generative priors to image inverse problems: conditional sampling and plug-and-play fusion methods. Finally, the talk outlines the core concepts and computational frameworks of generative algorithms for image inverse problems.

Boosting Adversarial Transferability via Multi-anchor Probability Manifold Priors

Schedule: July 7 15:00-15:30 Room 442

Yao Li

Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Yao Li

Abstract:

In real-world black-box attack scenarios, transferability is the primary threat vector. Targeted attacks, while of high practical importance, are notoriously difficult to transfer across models with heterogeneous architectures. This work introduces a Probability Manifold Framework that quantifies the intrinsic density of high-dimensional data by implicitly modeling the geometry of its underlying low-dimensional manifold. We theoretically prove that our density measure monotonically reflects the distance from a sample to the data manifold and demonstrate that guiding adversarial perturbations toward High-Sample-Density Regions (HSDR) is the optimal strategy for improving targeted transferability. To generalize this guidance to arbitrary feature topologies, we devise a topology-aware Multi-Anchor Softmin Strategy. This approach enables adaptive matching to valid high-density modes instead of forcing a rigid approximation to a single centroid, thereby avoiding low-density voids and accelerating convergence. Building on these innovations, we propose MAGMA (Multi-Anchor Generative Manifold Attack), a novel generative method for targeted attacks. Extensive experiments on ImageNet show that MAGMA sets a new state-of-the-art for generative attacks, substantially outperforming existing methods (e.g., TTP, ESMA) in average transfer success rate while also achieving significant gains in training efficiency.

Geometry-Aware Super-Resolution Imaging

Schedule: July 8 15:00-15:30 Room 442

Yutong Li

Tianjin Normal University, Peoples Rep of China

Abstract:

Super-resolution fluorescence microscopy enables nanoscale visualization of subcellular structures, high-performance reconstruction algorithms are imperative for further improving imaging quality. To improve the spatial resolution of fluorescence microscopy images, we present a deconvolution algorithm GEOREC, which is a robust and efficient super-resolution reconstruction framework. A background term is incorporated to achieve dynamic and precise removal of background fluorescence. We further integrate the geometric prior derived from shape operator in the model to preserve the sharp edges of the structure during denoising and background removal. In addition, we adopt a coarse-to-fine grid optimization strategy to significantly reduce computation time. Comprehensive evaluations on simulated data and real experimental images (microtubules, endoplasmic reticulum, Escherichia coli, etc.) demonstrate that GEOREC achieves high-fidelity and efficient super-resolution reconstruction and outperforms the state-of-the-art deconvolution methods.

A PCA Model for Surface Reconstruction from Point Clouds

Schedule: July 7 9:00-9:30 Room 442

Hao Liu

Hong Kong Baptist University, Hong Kong

Abstract:

Point cloud data represents a crucial category of information for mathematical modeling, and surface reconstruction from such data is an important task across various disciplines. In this presentation, we present our recent works for surface reconstruction from point cloud data. Our model utilizes a mean curvature term as regularizer. When the data are incomplete or noisy, a Principal Component Analysis (PCA) based variational model is proposed. Initially, we employ PCA to estimate the normal information of the underlying surface from the available point cloud data. This estimated normal information serves as a regularizer in our model, guiding the reconstruction of the surface, particularly in areas with missing data. An operator-splitting method is designed to effectively solve the proposed model. Through systematic experimentation, we demonstrate that our model is robust to noise, and successfully infers surface structures in data-missing regions and well reconstructs the underlying surfaces, outperforming existing methodologies.

Learned Spherical ADMM for Rician Noise Removal

Schedule: July 7 14:00-14:30 Room 442

Zhifang Liu

Tianjin Normal University, Peoples Rep of China

Abstract:

In this talk, we introduce a novel method called the learned spherical alternating direction method of multipliers (LSADMM). This method is designed to effectively remove Rician noise under spherical constraints. LSADMM unfolds the iterations of a proximal linearized ADMM solver into a deep neural network. The solver is originally used for a sphere-constrained variational model. The network alternates between lightweight, learnable gradient-descent modules and fixed, physics-based operators. Extensive numerical experiments are conducted on both synthetic and real-world datasets. The results show that LSADMM achieves competitive restoration performance. Its architecture is lightweight and requires substantially fewer parameters than conventional end-to-end deep learning methods.

Accelerating Imaging Inverse Problems with Data Sampling and Proximal Skipping

Schedule: July 8 14:30-15:00 Room 442

Evangelos Papoutsellis

Finden Ltd, University of Manchester, England

Abstract:

Large-scale imaging inverse problems are often limited by two expensive operations repeated at every iteration: gradient updates for the data-fidelity term and proximal evaluations for the regulariser. In this talk, we show how randomized proximal skipping and data splitting can substantially reduce this cost without sacrificing reconstruction quality. Numerical results on synthetic and real tomographic datasets demonstrate substantial runtime reductions, with speed-ups of 5x to 20x compared with standard approaches, while maintaining high-quality reconstructions.

A Tunable Despeckling Neural Network Stabilized via Diffusion Equation

Schedule: July 7 17:00-17:30 Room 442

Yi Ran

Harbin Institute of Technology, Peoples Rep of China

Abstract:

The removal of multiplicative Gamma noise is a critical research area in the application of synthetic aperture radar (SAR) imaging, where neural networks serve as a potent tool. However, real-world data often diverges from theoretical models, exhibiting various disturbances, which makes the neural network less effective. Adversarial attacks can be used as a criterion for judging the adaptability of neural networks to real data, since they can find the most extreme perturbations that make neural networks ineffective. In this work, we propose a tunable, regularized neural network framework that unrolls a shallow neural denoising block and a diffusion regularization block into a single network for end-to-end training. The linear heat equation, known for its inherent smoothness and low-pass filtering properties, is adopted as the diffusion regularization block. The smoothness of our outputs is controlled by a single time step hyperparameter that can be adjusted dynamically. The stability and convergence of our model are theoretically proven. Experimental results demonstrate that the proposed model effectively eliminates high-frequency oscillations induced by adversarial attacks. Finally, the proposed model is benchmarked against several state-of-the-art denoising methods on simulated images, adversarial samples, and real SAR images, achieving superior performance in both quantitative and visual evaluations.

A Damped Second-Order Flow for High-Order Segmentation Models with Efficient SAV Schemes

Schedule: July 7 15:30-16:00 Room 442

Shengzhu Shi

Harbin Institute of Technology, Peoples Rep of China

Abstract:

Traditional variational segmentation models are typically solved by deriving the corresponding gradient flow, which evolves the level set function along the steepest descent direction toward a stationary point. While such first-order flows often suffer from slow convergence and sensitivity to initialization, frequently becoming trapped in local minima. In recent years, damped second-order gradient flows have gained attention for their ability to accelerate convergence through inertial dynamics. In this paper, we investigate a damped second-order gradient flow for a class of high-order variational segmentation models. By incorporating a damping mechanism, the proposed flow achieves significantly accelerated convergence to stationary points compared to standard first-order methods. To address numerical challenges arising from nonlinearity and high-order derivatives, we develop efficient, unconditionally energy-stable schemes based on the scalar auxiliary variable method and its variants, ensuring long-time stability without restrictive time step constraints. Extensive experiments demonstrate that the proposed method not only accelerates convergence substantially but also exhibits improved robustness against initialization, effectively alleviating the local minima issue inherent in traditional level set approaches.

COFM: Physics-Informed Design of Input Convex Neural Networks for Consistency Optimal Transport Flow Matching

Schedule: July 7 18:00-18:30 Room 442

Fanghui Song

Harbin Institute of Technology, Peoples Rep of China

Abstract:

We propose a consistency model based on the optimal-transport flow. A physics-informed design of partially input-convex neural networks (PICNN) plays a central role in constructing the flow field that emulates the displacement interpolation. During the training stage, we couple the Hamilton Jacobi (HJ) residual in the OT formulation with the original flow matching loss function. Our approach avoids inner optimization subproblems that are present in previous one-step OFM approaches. During the prediction stage, our approach supports both one-step (Brenier-map) and multi-step ODE sampling from the same learned potential, leveraging the straightness of the OT flow. We validate scalability and performance on standard OT benchmarks.

An Effective Level Set Method With Molecular Beam Epitaxy Regularization for Color-Texture Image Segmentation

Schedule: July 6 16:30-17:00 Room 636

Jiebao Sun

Harbin Institute of Technology, Peoples Rep of China

Abstract:

We propose a novel variational model for color-texture image segmentation by embedding the molecular beam epitaxy (MBE) equation into a multi-cue segmentation (MCS) framework. The MBE equation incorporates a fourth-order diffusion term to smooth high-frequency noise while preserving curvature variations, along with a non-equilibrium term to ensure mass conservation and suppress oscillations, thereby eliminating the need for frequent reinitialization. Inspired by the physical principles of crystal film growth, this approach regulates the level set evolution by controlling thin-film growth dynamics, improving both stability and accuracy. We derive the gradient flow equation of the proposed model and prove the existence of a weak solution using the Galerkin approximation method. To solve the model efficiently, we design an implicit-explicit (IMEX) scheme, and employ an additive operator splitting (AOS) method to obtain the diffusion tensor. Extensive experiments demonstrate that the MBE-MCS model achieves more stable level set evolutions, better preserves fine structural details, and delivers superior segmentation accuracy, even for images with noise, sharp corners, and complex backgrounds.

A primal-dual splitting algorithm for monotone inclusions with applications

Schedule: July 7 17:30-18:00 Room 442

Yuchao Tang

Guangzhou University, Peoples Rep of China

Co-Author(s): Yuchao Tang

Abstract:

In this paper, we study a broad class of structured monotone inclusion problems in real Hilbert spaces. We propose a novel primal dual splitting algorithm for solving such inclusions, which accommodates multiple monotone operators, cocoercive terms, and composite monotone operators involving linear mappings. The algorithm combines forward evaluations for the cocoercive components with backward steps for the monotone operators, and incorporates a dual update to handle the linear composition term. Our framework generalizes and unifies several existing methods, while requiring only a single resolvent or operator evaluation per iteration, thereby maintaining computational efficiency. We establish weak convergence of the generated iterates under standard assumptions on monotonicity and cocoercivity. Furthermore, strong convergence is guaranteed under a mild regularity condition, such as uniform monotonicity. Finally, we present numerical experiments on structured convex and nonconvex optimization problems arising in image deblurring and denoising, which demonstrate the practical efficiency and flexibility of the proposed approach.

Learnable Mixture Distribution Prior for Image Denoising

Schedule: July 7 14:30-15:00 Room 442

Faqiang Wang

Beijing Normal University, Peoples Rep of China

Co-Author(s): Zhuoxiao Li, Li Cui, Jun Liu, Haiyang Huang

Abstract:

In variational-based image denoising, the regularizer derived from mixture distributions plays a crucial role in preserving image details. However, this type of mixture distribution priors has not been incorporated into deep learning-based denoising methods. In this talk, we give a method for learning regularizers based on a learnable Laplacian mixture distribution for image denoising. Our approach is motivated by the assumption that deep image features follow a latent distribution with a mixture model. To address this assumption, we propose a regularizer with learnable weights by considering the dual problem of maximum likelihood estimation for the deep features. The dual variable in this problem represents an attention weight, which can be learned using a numerical scheme with an unrolling technique. Notably, our method establishes a connection between the mixture distribution prior and the popular attention mechanism in deep learning. The results demonstrate the superior performance of our approach for image denoising.

Pediatric Disease Diagnosis Based on Multimodal Data Fusion

Schedule: July 7 16:30-17:00 Room 442

Yan Wang

Chongqing Normal University, Peoples Rep of China

Abstract:

This report will present some research progress of the research group in the field of pediatric disease diagnosis. In the diagnosis of abnormal conditions in children's lungs based on multimodal AI, the abnormal detection technology based on AE-FLOW and the medical image-text interaction platform will be introduced, and the clinical application of this topic will be discussed; In the work of brain cognition and rehabilitation for children with hyperactivity disorder, the research platform of the topic, database construction, and research on children's hyperactivity disorder based on brain functional imaging will be presented.

Identifying the order and a space source term in a time fractional diffusion-wave equation

Schedule: July 6 14:00-14:30 Room 636

Ting Wei

Lanzhou University, Peoples Rep of China

Co-Author(s): Ting Wei, Jianming Xu, Xi Yue

Abstract:

I will talk an inverse problem for identifying the order of time fractional derivative and a space-dependent source term in a time fractional diffusion-wave equation from some additional measured data in a subdomain or on a with a small time period. The Lipschitz continuity of forward operators mapping the unknown order and source term into the given data are established based on the stability estimates of solution for the direct problem. We prove the uniqueness of the considered inverse problems by using the asymptotic behavior of the solution at $t = 0$, the Titchmarsh convolution theorem and the Duhamel principle. Moreover, a Tikhonov-type regularization method is proposed with H^1 -norm as a penalty term. The existence of the regularized solution and its convergence to the exact solution under a suitable regularization parameter choice are obtained. Then we employ a linearized iteration algorithm combined with the piecewise linear finite element approximation to find simultaneously the approximate order and space source term. Three numerical examples for one- and two-dimensional cases are tested and the numerical results demonstrate the effectiveness of the proposed method.

A Physical-Model and Data-Driven Diffusion Method for PET/MRI Imaging

Schedule: July 7 18:30-19:00 Room 442

Taofeng Xie

Inner Mongolia Medical University, Peoples Rep of China

Co-Author(s): Chentao Cao, Zhuoxu Cui, Yu Guo, Caiying Wu, Xuemei Wang, Qingneng Li, Zhanli Hu, Tao Sun, Ziru Sang, Yihang Zhuo, Yanjie Zhu, Dong Liang, Qiyu Jin, Hongwu Zeng, Guoqing Chen, Haifeng Wang

Abstract:

PET/MRI provides critical multimodal information for diagnosing diseases like Alzheimer's. However, PET imaging faces challenges such as high costs, limited availability, and radiation risks from tracers. This report presents a novel framework that combines physical imaging models with data-driven diffusion models to improve PET/MRI accessibility and safety. We first propose an MRI-guided PET generation method based on Score-based Generative Models and Stochastic Differential Equations. This approach uses structural priors from MRI to synthesize high-quality PET images. Furthermore, we introduce a joint reconstruction method that integrates the Poisson noise characteristics of PET with the Gaussian noise of MRI. Experimental results across different magnetic field strengths demonstrate that our method significantly outperforms traditional GAN-based approaches in terms of signal-to-noise ratio and clinical accuracy. This research provides a robust technical path for low-dose, high-efficiency clinical imaging.

Topological Fingerprints of Tabular Surfaces in images Based on Persistent Homology

Schedule: July 6 13:30-14:00 Room 636

Xiaoping Yang

Nanjing University, Peoples Rep of China

Abstract:

Persistent homology is a crucial tool in topological data analysis (TDA), and the key to its applications lies in constructing a suitable finite-length ascending sequence of simplicial complexes (i.e., a filtration). Unlike most other approaches that directly apply persistence diagrams to downstream tasks, our core insight is that changes in the topological structure of simplicial complexes within a filtration are necessarily driven by specific vertices. We thus propose the concept of homology-generating/vanishing critical points, which aims to locate the vertices in the original data that induce topological changes in images. Subsequently, taking a novel geodesic filtration as an example, we investigate the relationships between 0-dim, 1-dim, and 2-dim PH points in persistence diagrams and the vertices in tubular structures of images. Experiments conducted on multiple datasets demonstrate that our method can accurately locate the homology-generating/vanishing critical points (e.g., branch points, endpoints, adhesions, etc.) and exhibits significant applications potential in relevant fields.

A time-fractional equation with the gray level indicator for image multiplicative noise removal

Schedule: July 6 18:30-19:00 Room 636

Wenjuan Yao

Harbin Institute of Technology, Peoples Rep of China

Abstract:

Synthetic aperture radar (SAR) images suffer from multiplicative noise, which significantly degrades their quality and visual effect. In this work, we propose a time-fractional equation with a gray level indicator for SAR image denoising. By introducing the time-fractional derivative, the model effectively interpolates between the heat and wave equations, preserving valuable information in highly oscillatory regions. Moreover, the fractional-order derivative operator possesses nonlocal properties, allowing for the inclusion of information from nonlocal domains. In order to achieve better control over the diffusion process, we incorporate a gray level indicator into the diffusion coefficients of our model, which allows us to fully take into account the gray level information of the image. We also investigate the well-posedness of the proposed model. Experiments on natural and real SAR images demonstrate the superiority of our method in removing multiplicative noise, particularly in highly oscillatory regions and texture-rich images.

Hierarchical Exact Solver for Large-scale Optimal Transport and its applications

Schedule: July 6 14:30-15:00 Room 636

Xiaoqun Zhang

Shanghai Jiao Tong University, Peoples Rep of China

Co-Author(s): Wenzhou Xia, Jingwei Liang, Qiaoqiao Ding

Abstract:

Optimal transport (OT) underlies many machine-learning and computer-vision tasks, yet solving large-scale OT problems under a tight memory budget remains challenging because of an inherent trilemma among precision, memory efficiency and dimensional scalability. To resolve this trade-off we propose a memory-efficient, dimension-scalable hierarchical exact solver for large-scale OT with low-rank cost. The proposed algorithm is a multi-resolution decomposition of the OT problem coupled with parallel-friendly linear-programming solvers. To guarantee memory efficiency we strictly bound the storage to linear complexity via active support pruning. Theoretically, we prove a scale-independent iteration-complexity upper bound for the refinement phase (consistent with the empirical observation) and show that, under standard assumptions, the algorithm converges to the global optimum. Numerical experiments demonstrate the scalability and exactness of the proposed algorithm across a wide range of regimes. The algorithm is capable to handle million-scale problems in very high dimensions ($n=106$, $d=8192$) on a single GPU, while still delivering exact solutions on synthetic high-dimensional data. The method thus alleviates the memory and scalability bottlenecks of existing solvers and resolves the precision-memory-dimensionality trilemma for large-scale OT.

Special Session 33 : Variational, Topological and Set-Valued Methods for Nonlinear Differential Problems

Organizer(s): Eleonora Amoroso , Franziska Borer , Patrick Winkert

Introduction: The focus of this session is the qualitative analysis of non-linear differential problems. In particular, the main purpose is to give an update on recent developments concerning ordinary and partial differential equations, variational-hemivariational inequalities, difference and algebraic systems obtained by exploiting different methods of the nonlinear analysis such as critical point theory, fixed point theorems, topological degree, Morse theory, set-valued analysis and so on.

The Prescribed Gauss Curvature Problem and its corresponding Flows

Schedule: July 8 13:30-14:00 Room 312

Franziska Borer

University of Technology Berlin, Germany

Co-Author(s): Esther Cabezas--Rivas, Peter Elbau, Tobias Weth, Patrick Winkert

Abstract:

In mathematics, there has long been an intrinsic motivation to formulate static problems in a flow context. Typically, elliptic theories are regarded as the static case of the corresponding parabolic problem; in that sense, many times the better-understood elliptic theory has been a source of intuition to generalise the corresponding results in the parabolic case. Examples for this duality are minimal surfaces and the mean curvature flow, harmonic maps and the solutions of the heat equation, as well as the Uniformisation Theorem and the two-dimensional normalised Ricci flow. In this talk, we give a glimpse into several results regarding the prescribed Gauss curvature problem---a problem raised by Kazdan and Warner dealing with the question which smooth functions $f : M \rightarrow \mathbb{R}$ arise as the Gauss curvature K_g of a conformal metric $g(x) = e^{2u(x)}\bar{g}(x)$ on a closed Riemannian manifold $(M, \bar{g})$ ---and its corresponding flows.

Qualitative results for elliptic systems with variable exponents

Schedule: July 8 17:00-17:30 Room 312

Maria-Magdalena Boureanu

University of Craiova, Romania

Co-Author(s): Alejandro Velez-Santiago

Abstract:

We investigate anisotropic elliptic systems with variable exponents governed by Leray-Lions type operators acting both in the domain and on its boundary. Using variational methods and various tools from the variable exponent analysis, we address the weak solvability of such systems. We prove existence, uniqueness, and global regularity of weak solutions, and illustrate our framework through relevant examples. This is a joint work with Alejandro Velez-Santiago.

Symmetry breaking for elliptic equations with exponential nonlinearities

Schedule: July 8 14:30-15:00 Room 312

Francesca Colasuonno

Universita degli Studi di Torino, Italy

Abstract:

Radially symmetric semilinear elliptic Dirichlet problems with exponential nonlinearities are considered in possibly unbounded domains of $\mathbb{R}^N$. For this class of problems, we prove the existence of a positive symmetry-breaking solution by using techniques in the spirit of Szulkin's nonsmooth critical point theory, applied within invariant convex cones.

Anisotropic Singular Logistic Equations

Schedule: July 8 14:00-14:30 Room 312

Leszek Gasinski

University of the National Education Commission, Poland

Abstract:

We consider a parametric Dirichlet problem driven by the anisotropic (p,q) -Laplacian and a reaction with a singular term and a superdiffusive logistic perturbation. We prove an existence and nonexistence theorem which is global with respect to the parameter.

The p -Laplacian obstacle problem with singular and discontinuous reaction term

Schedule: July 8 15:00-15:30 Room 312

Umberto Guarnotta

University of Catania, Italy

Co-Author(s): Annamaria Barbagallo

Abstract:

The talk is devoted to discuss existence and regularity of solutions to a p -Laplacian obstacle problem whose reaction is singular (i.e., it blows up when the solution approaches zero) and possesses a null-measure set of discontinuity points. The techniques presented are based on non-smooth calculus, convex analysis, monotonicity techniques, regularity theory, and locality properties.

Concentration Phenomena and Multi-bump Structures in Logarithmic p -Laplacian Equations

Schedule: July 8 8:30-9:00 Room 312

Lin Li

Chongqing Technology and Business University, Peoples Rep of China

Co-Author(s): Huo Tao, Patrick Winkert

Abstract:

This talk investigates a class of quasilinear Schrödinger equations involving the p -Laplacian operator and logarithmic nonlinearities. The presence of the singular term $u \log u^p$ renders the energy functional nonsmooth on standard Sobolev spaces, requiring the use of Szulkin's critical point theory and penalization methods.

Existence and localization results for elliptic problems with intrinsic operators

Schedule: July 8 15:30-16:00 Room 312

Angela Sciammetta

University of Palermo, Italy

Abstract:

The aim of this talk is to study a class of elliptic problems and systems characterized by the presence of intrinsic operators in the reaction terms. The main goal is to establish results on the existence and localization of solutions in frameworks where the nonlinearities depend on the function, its gradient, and an intrinsic operator. The approach is based on a suitable sub- and supersolution method.

A Leray-Lions approach to logarithmic double phase problems with natural growth terms

Schedule: July 8 16:30-17:00 Room 312

Matheus Stapenhorst

Universidade Estadual Paulista Julio de Mesquita Filho, Brazil

Co-Author(s): Marcos Tadeu de Oliveira Pimenta; Patrick Winkert

Abstract:

In this talk we will study problems involving the logarithmic double phase operator and a nonlinear term with natural growth. A solution to our problem is obtained as the limit of solutions to approximated problems, whose solutions exist by the Leray-Lions Theorem. The full result is obtained by carefully estimating certain terms associated to the pseudomonotonicity of the operator. This talk is based on a joint work with Marcos Tadeu de Oliveira Pimenta (Presidente Prudente, Brazil) and Patrick Winkert (Berlin, Germany).

Existence and concentration of ground state solutions for a Kirchhoff type problem involving the 1-Laplacian operator

Schedule: July 8 9:00-9:30 Room 312

Jijiang Sun

Nanchang University, Peoples Rep of China

Co-Author(s): Jiaqian Zhang and Jianjun Zhang

Abstract:

In this talk, we are concerned with the existence and concentration behavior of ground state solutions for the following Kirchhoff type equations involving the 1-Laplacian operator

$$\left(a + b \left(\int_{\mathbb{R}^N} \epsilon |Du| + \int_{\mathbb{R}^N} V(x) |u| \right)^{\alpha-1} \right) \left(-\epsilon \Delta_1 u + V(x) \frac{u}{|u|} \right) = f(u)$$

in $\mathbb{R}^N$, where $a, b > 0$, $N \geq 2$, $\epsilon > 0$ is a small parameter, $\alpha \in (1, \frac{N}{N-1})$, and the operator Δ_1 is the well known 1-Laplacian operator. Under suitable conditions on V and f , using non-smooth critical point theory, Lions' Concentration-Compactness Principle and some ingenious analyses, we first prove the existence of ground state solutions u_ϵ for a small parameter $\epsilon > 0$ in $BV(\mathbb{R}^N)$, the space of functions of bounded variation, which is the natural functional setting for the 1-Laplacian. Subsequently, we demonstrate that as $\epsilon \rightarrow 0$, this family of solutions concentrates around a global minimum of the potential V . This work is jointly with Jiaqian Zhang and Jianjun Zhang.

Remarks on positive solutions to a p -Laplacian problem with a possibly singular nonlinearity

Schedule: July 8 9:30-10:00 Room 312

Bruno Vassallo

University of Messina, Italy

Co-Author(s): Pasquale Candito and Giuseppe Failla

Abstract:

In this paper, we combine variational methods and truncation techniques to study the existence of a positive weak solution for a quasilinear elliptic problem driven by the p -Laplacian operator involving a reaction term which might or might not have a singularity at 0. Furthermore, provided that solutions belong to $C^1(\overline{\Omega})$, uniqueness is achieved using a $D\{i\}az-Sa\{a\}$ type argument, which relies on a Br\{e\}zis-Oswald assumption on the nonlinearity. Additionally, in the superlinear case, we give a multiplicity result that applies when an Ambrosetti-Rabinowitz type condition is fulfilled, e.g. in the concave-convex context.

Global regularity for Robin-type double phase boundary value problems

Schedule: July 8 17:30-18:00 Room 312

Alejandro Velez-Santiago

University of Puerto Rico - Rio Piedras Campus, USA

Co-Author(s): Angel Crespo-Blanco, Patrick Winkert

Abstract:

We are concerned with a inhomogeneous elliptic problem involving the double phase Laplace-type operator and Robin boundary conditions. Under minimal conditions on the coefficients and inhomogeneous data, we establish the first known result concerning the full global Hölder continuity of weak solutions.

Special Session 34 : Recent advances on integrable systems and related topics

Organizer(s): Xiaochuan Liu , Xiangke Chang , Bo Xue

Introduction: The study of integrable systems lies at the intersection of mathematics, physics, and nonlinear science, providing profound insights into the behavior of nonlinear waves, coherent structures, and dynamical systems. Integrable systems are characterized by their rich mathematical structures, including the presence of an infinite number of conserved quantities and symmetries, Lax-pair, exact solvability, and significant connections to algebraic geometry, dynamical systems, probability and special functions, etc. Integrable systems are essential for understanding nonlinear wave phenomena across various fields, including fluid dynamics, optics, condensed matter physics and string theory. This minisymposium aims to bring together researchers from diverse disciplines to explore recent advances, challenges and applications related integrable systems, while also offering an overview of current research activities in this area.

Rational solutions for algebraic solitons in the massive Thirring model

Schedule: July 8 8:00-8:30 Room 638

Cheng He

School of Mathematics and Statistics, Ningbo University, Peoples Rep of China

Co-Author(s): Zhen Zhao, Baofeng Feng, Dmitry E. Pelinovsky

Abstract:

We present an algebraic soliton of the massive Thirring model (MTM) as the simplest rational solution with spatial decay $\mathcal{O}(x^{-1})$; the corresponding potential relates to an embedded eigenvalue in the Kaup-Newell spectral problem. The hierarchy of rational solutions is studied: the N th member describes a nonlinear superposition of N algebraic solitons of equal mass and corresponds to an embedded eigenvalue of algebraic multiplicity N . Using double-Wronskian determinants, we rigorously prove that each solution is defined by a polynomial of degree N^2 with $2N$ free parameters, admitting $\frac{N(N-1)}{2}$ poles in the upper half-plane and $\frac{N(N+1)}{2}$ in the lower half-plane. Numerical root analysis shows that the N th member describes the slow scattering of N algebraic solitons on the time scale $\mathcal{O}(\sqrt{t})$.

On a generalized nonlocal shallow-water equation

Schedule: July 8 8:30-9:00 Room 638

Lili Huang

Chongqing Normal University, Peoples Rep of China

Abstract:

In this talk, we consider a quasilinear nonlocal shallow-water model equation for moderate-amplitude equatorial waves with effects of the weak Coriolis force and equatorial undercurrent. This mathematical modeling is analogous to the Camassa-Holm approximation of the two-dimensional incompressible and rotational Euler equations in the equatorial region. Moreover, we investigate the influences and interactions of the weak Coriolis force caused by the Earth rotation, vorticity and nonlocal higher nonlinearities on the wave-breaking phenomena. In certain cases, by applying the method of characteristics and extremal property of the solution to the Riccati-type differential inequality, we demonstrate that wave breaking phenomena occur only depending on a shape of wave initially in the local spacial point.

Point of constancy of the periodic linear Schrödinger equation

Schedule: July 8 9:00-9:30 Room 638

Jing Kang

Northwest University, Peoples Rep of China

Abstract:

In this talk, we investigate the points of constancy in the piecewise constant solution profiles of the periodic linear Schrödinger equation with step-function initial data at rational times. We characterize all points of constancy of the solution u and the square of the modulus $|u|^2$ of u , respectively. We employ number theoretic techniques, including quadratic Gauss sums and half-Gauss sums. These results establish an intriguing connections between the revival phenomena of dispersive evolution equations on a periodic domain and the classical number theory.

Painlevé XXXIV asymptotics for the defocusing nonlinear Schrödinger equation with a finite-genus algebro-geometric background

Schedule: July 8 13:30-14:00 Room 638

Gaozhan Li

Tsinghua University, Peoples Rep of China

Abstract:

In this paper, we consider the Cauchy problem for the defocusing nonlinear Schrödinger equation with a finite genus algebro-geometric background. Long-time asymptotics of the solution are derived in four space-time regions. It comes out that the leading-order term in the expansion is, up to a constant, given by the background solution with a shift of the parameter. The subleading term, however, decays at different rates for different regions. We particularly highlight that in the two transition regions, they are of order $\mathcal{O}(t^{-1/3})$ and the coefficients involve an integral of the Painlevé XXXIV transcendent. We establish our results by applying a nonlinear steepest descent analysis to the associated Riemann-Hilbert problems.

Oscillatory solutions of Camassa-Holm equation

Schedule: July 8 9:30-10:00 Room 638

Ruomeng Li

Zhengzhou University, Peoples Rep of China

Co-Author(s): Xianguo Geng, Abdul-Majid Wazwaz, Manxue Liu

Abstract:

A comprehensive and systematic method is introduced for deriving oscillatory N -breather solutions for the Camassa-Holm equation, which are a new class of solutions on the oscillatory backgrounds. The process of this method is divided into four distinct but interrelated stages: First, resorting to the Backlund transformations in Hirota's bilinear equations, a novel technique is devised to solve the spectral problems of a negative-order KdV equation involving theta-function potentials. Second, using these Backlund transformations, an N -fold Darboux transformation for the Camassa-Holm equation is rigorously formulated. Third, reciprocal and Darboux transformations are applied to construct oscillatory N -breather solutions for the Camassa-Holm equation from the spectral function of a negative-order KdV equation. Finally, the reality, boundedness, and smoothness of these novel solutions are rigorously established by expanding the Wronskians into Hirota summations.

On the nonlinear waves for the coupled complex mKdV system

Schedule: July 8 14:00-14:30 Room 638

Xiaochuan Liu

Xi'an Jiaotong University, Peoples Rep of China

Abstract:

In this talk, I will present some recent progress in the studies of nonlinear waves of the integrable coupled complex mKdV (ccmKdV) system. The general dark soliton solutions in pfaffian form are constructed and the link between the ccmKdV system and the BKP hierarchy is clarified. Furthermore, the multi-breather solutions are derived using the Kadomtsev-Petviashvili reduction method. This talk is based on the joint work with Professor Bao-Feng Feng and Dr. Chenxi Li.

Obliquely interacting solitary waves and wave wakes in free-surface flows

Schedule: July 8 14:30-15:00 Room 638

Xudan Luo

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

We investigate the weakly nonlinear isotropic bi-directional Benney-Luke (BL) equation, with a particular focus on soliton dynamics. The associated modulation equations are derived that describe the evolution of soliton amplitude and slope. By analyzing rarefaction waves and shock waves within these modulation equations, we derive the Riemann invariants and modified Rankine-Hugoniot conditions, which help characterize the Mach expansion and Mach reflection phenomena. We also derive analytical formulas for the critical angle and the Mach stem amplitude, showing that as the soliton speed is in the vicinity of unity, the results from the BL equation align closely with those of the Kadomtsev-Petviashvili (KP) equation. Furthermore, as a far-field approximation for the forced BL equation -- which models wave and flow interactions with local topography -- the modulation equations yield a slowly varying similarity solution. This solution indicates that the precursor wavefronts created by topography moving at subcritical or critical speeds take the shape of a circular arc, in contrast to the parabolic wavefronts observed in the forced KP equation.

Algebro-geometric solutions for the Ito hierarchy

Schedule: July 8 15:00-15:30 Room 638

Jiao Wei

Zhengzhou University, Peoples Rep of China

Co-Author(s): Minxin Jia, Xianguo Geng

Abstract:

This talk is about the Riemann theta function solutions for the Ito hierarchy. The Lax pair of the Ito hierarchy is derived from a 4×4 matrix spectral problem using the zero-curvature equation and Lenard equations. Then, we introduce the corresponding tetragonal curve and its Riemann theta function through the characteristic polynomial of the Lax matrix, and also discuss the construction of three kinds of Abelian differentials. Building on the theory of tetragonal curves, we investigate algebro-geometric properties of Baker-Akhiezer functions and fundamental meromorphic functions. Finally, Riemann theta function solutions for the entire Ito hierarchy are derived via asymptotic analysis.

On the algebraic structure of Kadomtsev-Petviashvili hierarchies with constraints

Schedule: July 8 15:30-16:00 Room 638

ZHIWEI WU

Sun Yat-sen University, Peoples Rep of China

Co-Author(s): Song Li, Kelei Tian

Abstract:

In this talk, we will discuss the construction of KP hierarchies with constraints under the scheme of loop group. Matrix representations of corresponding pseudo-differential operators are given. To illustrate this process, we will give an example which is a generation of the constraint KP. Darboux transformation is constructed and formulas connecting Tau functions and formal inverse scattering solutions are given.

Critical asymptotics for the semiclassical Camassa-Holm equation at the point of gradient catastrophe

Schedule: July 8 16:30-17:00 Room 638

Yiling Yang

Chongqing University, Peoples Rep of China

Co-Author(s): Taiyang Xu and Lun Zhang

Abstract:

We investigate the Cauchy problem for the Camassa-Holm (CH) equation with a small dispersion parameter $\epsilon > 0$. Under a negative analytic initial data, we prove that before a certain time, the solution could be well approximated by the solution to Hopf equation which corresponds to $\epsilon = 0$. Near the point of gradient catastrophe to the Hopf equation, we show that the solution of CH equation is approximated by a particular Painlevé transcendent in the double scaling limit. This proves the validity of the Dubrovin conjecture concerning the critical asymptotics for a broad class of Hamiltonian perturbative hyperbolic equations. We established our results by performing the steepest descent analysis to an associated Riemann-Hilbert problem.

Controllable rogue waves on the Jacobi-periodic background for the higher-order nonlinear Schrodinger equation

Schedule: July 8 17:00-17:30 Room 638

Yunfei Yue

Chongqing Technology and Business University, Peoples Rep of China

Abstract:

In this talk, we have systematically studied rogue wave solutions on elliptic function backgrounds for the higher-order nonlinear Schrodinger equation. By utilizing the Darboux transformation and the nonlinearization method of Lax pairs, we have derived first and second-order rogue wave solutions on cn- and dn-periodic backgrounds. Their dynamical behavior have analyzed in detail and illustrated them through graphics.

Statistical mean and variance analysis for the dynamical behaviors of stochastic Boussinesq equations

Schedule: July 8 17:30-18:00 Room 638

Haiqiong Zhao

Shanghai University of International Business and Economics, Peoples Rep of China

Co-Author(s): Hai-qiong Zhao

Abstract:

Some stochastic Boussinesq equations under Brown motion are investigated. The integrability of the stochastic Boussinesq equations are established by demonstrating the existence of a Lax pair. By using the Darboux transformation, we construct a variety of exact solutions, including multi-soliton solutions, periodic solutions and rational solutions, under integrated Brownian motion. Most importantly, the dynamic behaviors of the stochastic soliton solutions are analyzed through two key probabilistic characteristics: the statistical mean and variance. Specifically, the long-time asymptotic expressions for these characteristics are rigorously derived, revealing a high degree of consistency with the statistical mean and variance obtained from sampled solutions.

Special Session 35 : Elliptic PDEs: singularities, discontinuities, and nonlinear phenomena

Organizer(s): Umberto Guarnotta , Salvatore Angelo Marano

Introduction: This special session focuses on recent advances in the study of elliptic partial differential equations, with a particular emphasis on problems exhibiting reaction terms which are singular, discontinuous, or model some nonlinear phenomena. Such types of problems naturally arise in a wide range of scientific areas, including physics, engineering, chemistry, and biology, and their solutions often exhibit complex and challenging behaviors. Topics of interest include, but are not limited to: - Existence, regularity and qualitative properties of solutions to elliptic equations or systems; - Developments and new trends in variational methods; - Set-valued analysis and fixed point theory; - Problems with lack of compactness (problems in the whole space, critical problems, Hardy-type potentials); - Elliptic problems with non-local behavior; - Applications of elliptic PDEs to real-world problems. We welcome contributions from researchers working in all areas of elliptic PDEs, including both theoretical and applied aspects.

The nonlinear fractional relativistic Schrodinger-Choquard equation

Schedule: July 7 18:00-18:30 Room 434

Vincenzo Ambrosio

Universita' Politecnica delle Marche, Italy

Abstract:

In this talk, I will consider the doubly nonlocal nonlinear elliptic equation $(-\Delta + m^2)^s u + \omega u = (I_\alpha * F(u))F'(u)$ in $\mathbb{R}^N$, where $N \geq 2$, $s \in (0, 1)$, $m > 0$, and $\omega > -m^{2s}$. Here, $(-\Delta + m^2)^s$ denotes the fractional relativistic Schrodinger operator, I_α is the Riesz potential of order $\alpha \in (0, N)$, and $F : \mathbb{R} \rightarrow \mathbb{R}$ is a C^1 -nonlinearity of Berestycki--Lions type. I will discuss the existence of least energy solutions, as well as their qualitative properties, including regularity, decay, sign, and symmetry.

Dirichlet boundary value problems governed by non-monotone differential operators

Schedule: July 7 14:30-15:00 Room 434

Francesca Anceschi

Universita' Politecnica delle Marche, Italy

Abstract:

We prove existence results for Dirichlet boundary value problems for nonlinear possibly singular equations involving a generic possibly non-monotone differential operator defined in a open interval J . Also, under very mild assumptions, we prove the existence of solutions for suitably prescribed boundary conditions, and we also address the study of the existence of heteroclinic solutions on the half-line. These results are part of a joint work with C. Marcelli and F. Papalini.

Gradient regularity for quasilinear elliptic problems

Schedule: July 6 17:00-17:30 Room 434

Carlo Alberto Antonini

University of Milan (UniMi), Italy

Abstract:

In this talk we will deal with quasilinear elliptic equations in divergence form $-\operatorname{div}(\mathcal{A}(x, Du)) = f$, modeled upon the p -Laplace and, more generally, the Orlicz-Laplace operator. We will discuss gradient regularity of solutions, both in the interior and up to the boundary, under Dirichlet or Neumann boundary conditions.

Critical double phase Kirchhoff problems in

$\mathbb{R}^N$

Schedule: July 6 15:30-16:00 Room 434

Giuseppina Autuori

Polytechnic University of Marche, Italy

Co-Author(s): Teresa Isernia

Abstract:

In this talk we will discuss the existence of groundstate solutions for certain critical Kirchhoff problems governed by a double phase operator in $\mathbb{R}^N$, involving a bounded periodic potential, a positive weight and a reaction term. Under suitable growth and monotonicity assumptions, we prove an existence result according to the size of a positive parameter λ , without the Ambrosetti--Rabinowitz condition, in the setting of Musielak--Orlicz spaces. Our proof technique relies on variational arguments including the Mountain Pass Theorem, the Nehari manifold method, concentration compactness results and the use of a suitable limiting problem. The talk is based on a joint work with Teresa Isernia.

The obstacle problem for the p -Laplacian

Schedule: July 7 9:30-10:00 Room 434

Annamaria Barbagallo

University of Naples Federico II, Italy

Co-Author(s): Umberto Guarnotta

Abstract:

The purpose of the talk is to prove the existence of a solution to the obstacle problem involving the p -Laplacian operator, in a setting where the reaction term is singular at zero and exhibits strong discontinuities. Notably, no restriction is placed on the discontinuity set having zero Lebesgue measure. Lastly, it is shown that the solution lies in the space $C^{1,\alpha}$ outside the contact set.

Boundedness of solutions to Dirichlet, Neumann, Robin and mixed problems for elliptic equations in Orlicz spaces

Schedule: July 7 15:00-15:30 Room 434

Giuseppina G. Barletta

University of Reggio Calabria, Italy

Co-Author(s): A. Cianchi, G. Marino, E. Tornatore

Abstract:

We present some boundedness results for boundary value problems for second-order elliptic equations in divergence form. We examine different boundary conditions and highlight the decisive role played by optimal forms of Orlicz-Sobolev embeddings and boundary trace embeddings, which allow for critical growths of the coefficients.

Quasi-variational inequalities with non compact constraints

Schedule: July 6 14:00-14:30 Room 434

Irene Benedetti

Department of Mathematics and Computer Science, University of Perugia, Italy

Abstract:

This talk deals with generalized quasi-variational inequalities, namely problems involving a multivalued operator and a constraint set depending on the solution itself. These models arise in several applications, including equilibrium theory, optimization, and problems related to elliptic equations. We present new existence results obtained under weaker assumptions than those typically required in the literature. In particular, we relax both the compactness conditions on the constraint set and the regularity assumptions on the multivalued operator. The approach is based on tools from nonlinear functional analysis and fixed point theory. Our results extend the classical framework and provide a more flexible setting for the analysis of quasi-variational inequalities.

Some recent results on singular anisotropic elliptic equations

Schedule: July 7 14:00-14:30 Room 434

Barbara Brandolini

Universita' degli Studi di Palermo, Italy

Abstract:

In this talk, we discuss some recent results on the existence and uniform boundedness of solutions for a general class of Dirichlet anisotropic elliptic problems, defined in open bounded subsets of $\mathbb{R}^N$ ($N \geq 2$), and driven by the so-called $\vec{p}$ -Laplacian operator, where $\vec{p} = (p_1, p_2, \dots, p_N)$, with $N/p = \sum_{k=1}^N (1/p_k) > 1$. The feature of this study is the inclusion of a possibly singular gradient-dependent term $\Psi(u, \nabla u) = \sum_{j=1}^N |u|^{\theta_j-2} u |\partial_j u|^{q_j}$, where $\theta_j > 0$ and $0 \leq q_j < p_j$ for $1 \leq j \leq N$. We also investigate the case $q_j = p_i$ for every $1 \leq j \leq N$ in the singularity-free case, and we prove the existence of a solution with a further regularity of exponential type. Based on joint works with Florica C. Cirstea (The University of Sydney, Australia) and V. Ferone (Università degli Studi di Napoli Federico II).

On the weak Harnack inequality for a generalized Orlicz De Giorgi class

Schedule: July 6 13:30-14:00 Room 434

Simone ciani

University of Bologna Alma Mater, Italy

Co-Author(s): Eurica Henriques, Igor I. Skrypnik

Abstract:

We introduce a generalization of De Giorgi classes with Orlicz growth. The aim is twofold: on the one hand, to encompass a broader class of functionals and equations; on the other hand, to provide a definition based on a simple energy inequality that does not rely on an underlying functional, but rather on the intrinsic scaling between radii and levels. For these classes, we establish a Weak Harnack inequality, thereby unifying its validity across non-uniformly elliptic equations, double-phase and degenerate double-phase functionals, as well as functionals with variable exponents.

Comparison results for the fractional heat equation with a singular lower order term

Schedule: July 7 15:30-16:00 Room 434

Ida de Bonis

Sapienza University of Rome, Italy

Abstract:

We provide symmetrization results in the form of mass concentration comparisons for fractional singular parabolic equations in infinite cylinders of the type $\Omega \times (0, T)$, where $\Omega \subset \mathbb{R}^N$, $N \geq 2$ is a bounded, open set with Lipschitz boundary, and $T > 0$. The results are obtained in collaboration with B. Brandolini, V. Ferone and B. Volzone.

Asymptotic behavior as

p
to 1

of solutions to p -Laplacian problems in presence of convection and drift terms

Schedule: July 7 9:00-9:30 Room 434

Riccardo Durastanti

Universita degli Studi di Napoli Federico II, Italy

Abstract:

We deal with the asymptotic behavior as $p \rightarrow 1^+$ of weak solutions to nonlinear Dirichlet problems modeled by

$$\begin{cases} -\Delta_p u + |u|^{p-1}u = -\operatorname{div}(|u|^{p-2}u E(x)) + |\nabla u|^{p-2} \nabla u \cdot F(x) + f(x) & \text{in } \Omega, \quad u=0 \text{ on } \partial\Omega, \end{cases}$$

where Ω is an open bounded subset of $\mathbb{R}^N$ ($N \geq 2$). We focus on the a priori estimates depending on the norm of the Lebesgue functions E, F and f which guarantee the existence of a limit problem in the framework of functions of bounded variation. This is a joint work with Francescantonio Oliva.

First eigenvalue and torsional rigidity: isoperimetric inequalities for the fractional Laplacian

Schedule: July 7 13:30-14:00 Room 434

Vincenzo Ferone

Università di Napoli Federico II, Italy

Abstract:

We present a fractional counterpart of a generalized Kohler-Jobin inequality, showing that, among all bounded, open sets $\Omega \subset \mathbb{R}^N$ with Lipschitz boundary, having the same fractional torsional rigidity, the first Dirichlet eigenvalue $\lambda_1(\Omega)$ of the fractional Laplacian attains its minimum on balls. With the same arguments we also establish a reverse Hölder inequality for an eigenfunction corresponding to $\lambda_1(\Omega)$. The results have been obtained in collaboration with B. Brandolini, I. de Bonis, G. Piscitelli and B. Volzone.

On Bobkov-Tanaka type spectrum for the double-phase operator

Schedule: July 6 15:00-15:30 Room 434

Laura Gambera

University of Catania, Italy

Co-Author(s): Umberto Guarnotta

Abstract:

In this talk, based on joint work with U. Guarnotta, we study an eigenvalue problem for a double-phase operator. The lack of homogeneity of $\Delta_p^a + \Delta_q$ makes the notion of spectrum non-unique, allowing for different possible definitions, as already occurs for the (p, q) -Laplacian. We adopt a notion of spectrum inspired by the Fucik spectrum, following an approach previously introduced by Bobkov and Tanaka. A key point is that the structure of the spectrum depends strongly on the linear independence condition $\phi_p^a \neq k\phi_q$ for every $k \in \mathbb{R}$, leading to different spectral configurations depending on whether this condition holds. The problem exhibits several features, including the lack of homogeneity, unbalanced growth placing it in the Musielak-Orlicz framework, and the presence of a non-negative, non-trivial weight $a \in C^{0,1}(\Omega)$, which leads to a loss of local regularity. We discuss the region of parameters in which existence or non-existence of positive solutions occurs. The analysis relies on normalization arguments, the Nehari manifold, and truncation techniques, combined with Picone-type inequalities and a suitably tailored strong maximum principle.

Normalized solutions for Elliptic PDEs

Schedule: July 6 14:30-15:00 Room 434

Divya Goel

Indian institute of Technology BHU, India

Abstract:

Normalized solutions for elliptic PDEs are sought under a prescribed mass constraint and appear naturally in models from nonlinear physics. In this talk, we will discuss recent results for normalized solutions to nonlinear elliptic problems involving Kirchhoff, Choquard, fractional, and weighted Caffarelli-Kohn-Nirenberg type operators. The focus will be on variational methods under mass constraint, where critical growth, nonlocal effects, and loss of compactness create significant difficulties. Using Pohozaev-type identities, fibering maps, and minimax arguments, one can establish existence, multiplicity, and ground state solutions in several regimes. These results demonstrate that constrained variational techniques provide a unified framework for studying normalized solutions in modern elliptic PDEs.

Multiple positive and negative energy solutions for (p, q) -Kirchhoff critical equations in $\mathbb{R}^N$

Schedule: July 7 18:30-19:00 Room 434

Teresa Isernia

Universita' Politecnica delle Marche, Italy

Co-Author(s): Giuseppina Autuori and Letizia Temperini

Abstract:

In this talk, we deal with a class of nonlocal (p, q) -Kirchhoff equations in $\mathbb{R}^N$ involving competing nonlinearities and a critical growth term. The interplay between the nonlocal Kirchhoff coefficient and the combined action of subcritical and critical nonlinearities leads to a rich variational structure, making the analysis particularly delicate. We focus on the existence and multiplicity of solutions, highlighting how the behavior of the system strongly depends on the interplay between the exponents and the parameter λ . In particular, we identify different regimes in which multiple solutions arise, corresponding to negative and positive energy levels, and driven by either small or large values of λ , as well as suitable conditions on the weight functions. Our results significantly extend and refine existing results on (p, q) -Kirchhoff problems with critical growth. This talk is based on a joint work with Giuseppina Autuori and Letizia Temperini.

Recent advances in the regularity of some classes of elliptic systems of PDEs

Schedule: July 6 18:00-18:30 Room 434

Salvatore Leonardi

University of Catania, Italy

Abstract:

We present an overview of several regularity results for specific classes of elliptic systems established in recent years. Specifically, employing the Einstein summation convention, we investigate the following system:

$$\begin{cases} u \in \mathcal{W} \\ -\operatorname{Di} A_i^\nu(x, u, \operatorname{DD}u) = -\operatorname{Di}(E_i(x) u^\nu) + f^\nu(x), \quad x \in \Omega, \nu = 1, \dots, N \end{cases}$$

defined on a domain $\Omega \subset \mathbb{R}^n$ ($n \geq 3$, $N \geq 2$), where A_i^ν and $E_i(x)$ are required to satisfy appropriate structural and integrability conditions. The analysis further assumes that the data f^ν belong to the Lebesgue space $L^t(\Omega)$ for $\nu = 1, \dots, N$, with $t \geq \frac{2n}{n+2}$.

Remarks on maximum principle

Schedule: July 6 17:30-18:00 Room 434

Francesco Leonetti

University of L'Aquila, Italy

Abstract:

Maximum principle can be obtained for solutions to elliptic equations. De Giorgi's counterexample says that this is no longer true for systems, but, despite that, it is possible to get maximum principle for solutions to some systems.

Multiplicity of mountain-pass type transition solutions for Lagrangian systems with double-well potentials

Schedule: July 6 18:30-19:00 Room 434

Piero Montecchiari

Universita' Politecnica delle Marche, Italy

Abstract:

We present several results concerning the multiplicity of heteroclinic and homoclinic solutions of mountain-pass type for non-autonomous Lagrangian systems of Allen-Cahn type. In particular, we show that, under natural non-degeneracy assumptions, multi-transition local minimizers generate distinct local mountain-pass structures, giving rise to multiple associated mountain-pass type solutions.

1-Laplace Dirichlet problems involving first order terms

Schedule: July 7 8:30-9:00 Room 434

Francescantonio Oliva

Sapienza university of Rome, Italy

Abstract:

In this talk, we discuss the existence and qualitative behavior of bounded variation (BV) solutions to Dirichlet problems driven by the 1-Laplace operator. We deal with general, and possibly singular, first-order nonlinearities and we focus on how these nonlinearities play a regularizing effect on the solutions. In particular, we study the role of the gradient nonlinearity in the attainment of the homogeneous boundary condition for the solutions.

Scaling-based existence and multiplicity results for double phase problems in $\mathbb{R}^N$

Schedule: July 6 16:30-17:00 Room 434

Kanishka Perera

Florida Institute of Technology, USA

Co-Author(s): Francesca Colasuonno, Patrick Winkert

Abstract:

We present new existence and multiplicity results for the double phase problem

$$\mathcal{A}(u) := -\operatorname{div} \left(|\nabla u|^{p-2} \nabla u + |x|^{-b} |\nabla u|^{q-2} \nabla u \right) = f(|x|, u)$$

with

$$u \in \mathcal{D}_{\operatorname{rad}}^{1,p}(\mathbb{R}^N) \cap \mathcal{D}_{\operatorname{rad}}^{1,q}(\mathbb{R}^N; |x|^{-b}),$$

where $1 < p < q < N$, $0 \leq b < N - q$, and f is a Carathéodory function on $[0, \infty) \times \mathbb{R}$ that satisfies a suitable growth condition. Our results are based on certain scaling properties of the operator $\mathcal{A}$ and recently developed variational methods for scaled functionals.

Optimal Global BV Regularity for 1-Laplace type BVP's with Singular Lower Order Terms

Schedule: July 7 8:00-8:30 Room 434

Francesco Petitta

Sapienza, University of Rome, Italy

Abstract:

This talk investigates the optimal regularity for solutions to singular elliptic equations involving the 1-Laplace operator. We analyze a class of problems whose model case is $-\Delta_1 u = f(x)u^{-\gamma}$ with homogeneous Dirichlet boundary conditions. In contrast to the classical p -Laplacian case with $p > 1$, we prove that the structure of the 1-Laplacian guarantees global BV regularity of the solutions for any power $\gamma > 0$. We will show how a priori estimates based on truncation arguments allow us to handle the boundary discontinuity issue and to control the effects arising from the domain's curvature.

Normalised solutions to a fractional Schrödinger equation in the strongly sublinear regime

Schedule: July 7 17:00-17:30 Room 434

Jacopo Schino

University of Warsaw, Poland

Co-Author(s): Marco Gallo

Abstract:

Schrödinger-type equations model a lot of natural phenomena and their solutions have interesting and important properties. One of them is the conservation of mass, which gives rise to the search for normalised solutions. In this talk, I will explain a possible approach to solve a fractional equation paired with a constraint on the L^2 norm. The context includes the so-called strongly sublinear regime, i.e., when the RHS has a negative sublinear growth at the origin. This makes a direct variational approach impossible because the energy functional is not well-defined in $H^s(\mathbb{R}^N)$. In the proposed approach, when the mass is sufficiently large, a family of approximating problems is considered so that the energy functional is of class C^1 and a corresponding family of solutions is obtained, which eventually converge to a solution to the original problem. In the strongly sublinear regime, the previous result for a suitably translated problem is exploited to obtain a solution for any mass.

Nonlocal operators in divergence form and existence results for L^1 data

Schedule: July 7 17:30-18:00 Room 434

Caterina Sportelli

Universidad de Granada, Spain

Abstract:

In this talk, we study the existence and uniqueness of weak solutions to Dirichlet boundary value problems driven by a nonlocal operator in divergence form with data in $L^1(\Omega)$ that are suitably dominated. Moreover, we show that, as $s \nearrow 1$, the nonlocal solutions converge to the solution of the corresponding local problem, thereby recovering the classical theory as a limit case. The results presented in this talk are based on \cite{MR5007887}. \bib{MR5007887} Arcoya, David, Dipierro, Serena, Proietti Lippi, Edoardo, Sportelli, Caterina, Valdinoci, Enrico, Nonlocal operators in divergence form and existence theory for integrable data, J. Funct. Anal., 290, 2026, 7, Paper No. 111317, 58, issn 0022-1236, MR{5007887}, doi{10.1016/j.jfa.2025.111317},

Existence results for logarithmic double phase problems with nonlinear Neumann boundary conditions

Schedule: July 7 16:30-17:00 Room 434

Patrick Winkert

University of Technology Berlin, Germany

Abstract:

In this talk, we present several existence results for logarithmic double phase problems with nonlinear Neumann boundary conditions. By introducing a new and very general equivalent norm in the logarithmic Musielak-Orlicz Sobolev space, we discuss different types of nonlinearities on the boundary, including critical growth. This talk is based on joint works with Franziska Borer (Berlin), Yino B. Cueva Carranza (Presidente Prudente), Leszek Gasiński (Krakow), Marcos T.O. Pimenta (Presidente Prudente), Eytem Ozturk (Ankara) and Matheus F. Stappenhorst (Presidente Prudente).

Special Session 37 : Recent development of stochastic optimal control, applications and deep learning methods

Organizer(s): Omar KEBIRI

Introduction: Stochastic optimal control has been developing very fast in the recent years. It has the attention of many applications in epidemic, economy, finance, biology and many other fields, especially in the recent researches areas, such as deep and machine learning. This special session is to present recent developments of stochastic optimal control and their applications in finance, economy and deep learning methods for solving stochastic dynamical systems, such as BSDEs, 2BSDE, Reflected BSDE ... etc. The main topics are focused on, but are not limited to: -1- Stochastic Optimal Control in Mathematical Finance -2- Machine learning methods for solving control problems -3- Optimal insurance strategy -4- Stochastic maximum principle -5- Uncertainty quantification models and their numerical analysis. -6- Stochastic homogenization. -8- Fractional, sub-fractional and multi-fractional stochastic differential equations and their applications.

Exponential Convergence of Relative Value Iteration in Ergodic Control Problems in Diffusions

Schedule: July 7 15:00-15:30 Room 436

Sumith Reddy Anugu

TU Ilmenau, Germany

Co-Author(s): Sumith Reddy Anugu (TU Ilmenau), Guodong Pang (Rice University)

Abstract:

The relative value iteration (RVI) algorithm is well-known to numerically approximate the value function (and also the optimal value) associated with ergodic cost control problems and thereby also help us obtain the approximations of optimal controls. However, the rate of convergence of these algorithms is less explored in the case of infinite state space like in diffusions, even under strong conditions of exponential ergodicity. In this talk, we present our recent work where we establish that a 'slightly modified version' of the RVI algorithm in the case of diffusions converges exponentially, under the conditions of uniform exponential ergodicity of the diffusion. The proof involves considering a weighted semi-norm which is identical for all functions modulo an additive constant. It turns out that under this semi-norm, the diffusion semi-group becomes a contraction, uniformly in all Markov controls. Another consequence of this consideration is that one effectively 'decouples' the problem of convergence to the optimal value and the problem of convergence to the value function. We then analyze both these convergences separately.

Deep Learning for Energy Market Contracts: Dynkin Game with Doubly RBSDEs

Schedule: July 7 18:00-18:30 Room 436

Ihsan Arharas

Linnaeus University, Sweden, Sweden

Co-Author(s): Nacira Agram, Giulia Pucci and Jan Rems

Abstract:

We formulate a Contract for Difference (CfD) with early exit options as a two-player zero-sum Dynkin game, capturing the strategic interaction between an electricity producer and a regulatory authority. The payoff structure includes running revenues, early termination penalties, and a terminal settlement, while the underlying electricity prices follow mean-reverting dynamics. The value of the game and the associated feedback optimal stopping rules are characterized through a doubly reflected backward stochastic differential equation (DRBSDE). To approximate the solution of the DRBSDE, we propose a learning-based numerical method that combines time discretization with neural network approximations of the backward components along simulated price trajectories. The approach avoids explicit state space discretization, accommodates time dependent barriers, and is applicable in moderately high-dimensional settings. A convergence result is established to justify the link between the continuous-time formulation and its numerical approximation. The proposed Deep DRBSDE solver is illustrated on a CfD model driven by 24-dimensional mean-reverting electricity prices representing multiple European market zones. In addition, a symmetric benchmark Dynkin game in dimension~20 and a mean-field extension are considered to assess the validity of the solver in controlled settings. The numerical results demonstrate stable training behavior and a consistent approximation of the contract value and optimal stopping regions across the considered examples.

Pontryagin Maximum Principle for Reflected BSDEs under State Constraints

Schedule: July 6 17:30-18:00 Room 436

Hanane Ben-Gherbal

University of Mohamed Khider, Biskra, Algeria

Co-Author(s): Omar Kebiri

Abstract:

In this talk, we investigate a stochastic optimal control problem in which the performance criterion is described by a reflected backward stochastic differential equation (RBSDE) subject to a lower obstacle. The reflection mechanism introduces intrinsic nonsmoothness, which prevents the direct application of standard variational techniques. To address this difficulty, we employ a penalization method, approximating the RBSDE by a sequence of classical BSDEs augmented with penalization terms. Combining spike variation arguments with duality techniques, we establish a Pontryagin-type maximum principle for the penalized systems and subsequently pass to the limit. In the limiting framework, we derive a novel adjoint equation that involves a singular measure concentrated on the contact set where the reflection constraint is active. This measure can be interpreted as a stochastic counterpart of a Lagrange multiplier, yielding a rigorous Hamiltonian formulation of the maximum principle under state inequality constraints. In this talk, we also illustrate the theoretical results with a representative example.

Modeling Long-Memory Stochastic Dynamics in a Fractional SIRV³S Epidemic System

Schedule: July 7 17:30-18:00 Room 436

Khelifa Berkane

University of BTU Cottbus-Senftenberg, Germany

Co-Author(s): Omar Kebiri ; Abdeldjebbar Kandouci ; Carsten Hartmann ; Mhamed Eddahbi

Abstract:

We investigate a novel epidemic model known as the SIRV³S model, which incorporates three types of vaccinations and introduces stochastic perturbations in one of our key parameters, considering the presence of a long-memory effect. This formulation enables us to express our model as a stochastic differential equation driven by fractional Brownian motion with a Hurst parameter ($H > \frac{1}{2}$), which we denote as FSDE. By employing the Wick-It^o-Skorohod (WIS) integral framework, we establish the existence and uniqueness of a global positive solution using the random Lyapunov function method in conjunction with It^o's formula. In our numerical modelling, we examine an example based on the COVID-19 epidemic. Our objective is to ascertain the most appropriate Hurst parameter for our specific context. To achieve this objective, we first generate fractional Brownian motion utilising the fast Fourier transform method. Following this step, we apply an Euler-type discretisation tailored to the increments of fractional Brownian motion. Throughout this simulation, we compare three distinct Hurst parameters. Through these comparisons, we identify the parameter that best corresponds to our particular scenario.

Quadratic BSDEs Subject to Irregular Obstacle Constraints

Schedule: July 6 17:00-17:30 Room 436

El Hassan ES-SAKY

Cadi Ayyad University, Polydisciplinary Faculty of Safi, Morocco

Co-Author(s): E.H. Essaky, M. Hassani, C.E. Rhazlane

Abstract:

This talk establishes the existence of maximal (and minimal) solution for one-dimensional generalized reflected backward stochastic differential equation (RBSDE for short). The equation features irregular barriers and a driver with stochastic quadratic growth. The solution Y is constrained to remain above rcll barriers L and U on $[0, T[$, while its left limit Y_- must stay above predictable barriers l and u on $]0, T]$. This result is achieved without assuming any $\mathbb{P}$ -integrability conditions and under weaker assumptions on the input data. In particular, we construct a maximal solution for such a RBSDE when the terminal condition ξ is only $\mathcal{F}_T$ -measurable and the driver f is continuous with general growth with respect to the variable y and stochastic quadratic growth with respect to the variable z . Our proof is based on a generalized penalization method. Furthermore, we present a standard and equivalent formulation of the original RBSDE and characterize the solution Y as the generalized Snell envelope of a specific predictable process l .

Financial Modeling with Stochastic Volatility: Connections to 2BSDEs and Deep Learning Methods

Schedule: July 7 13:30-14:00 Room 436

Omar KEBIRI

BTU Cottbus-Senftenberg, Germany

Co-Author(s): Zaineb Mezoud, Carsten Hartmann, Mohamed Riad Remita

Abstract:

In this talk, we present modeling of financial dynamics under uncertainty through stochastic volatility frameworks. We introduce several stochastic models, with a particular focus on an α -hypergeometric model with uncertain volatility (UV), and investigate the corresponding worst-case scenario for option pricing. Our approach relies on the connection between a class of nonlinear Hamilton-Jacobi-Bellman (HJB) type partial differential equations, namely G-HJB equations, which characterize the nonlinear expectation in the UV setting and second-order backward stochastic differential equations (2BSDEs). This framework provides an alternative to the challenging calibration issues inherent in uncertain volatility models. Using asymptotic analysis of the G-HJB equation and its equivalent 2BSDE representation, we derive a limiting model that accurately captures the worst-case pricing scenario when the volatility bounds vary slowly. Finally, the theoretical results are supported by numerical experiments based on deep learning methods for approximating the associated 2BSDE, demonstrating the effectiveness of the proposed approach.

Stochastic optimal control of battery storage with SEI driven degradation in volatile electricity markets.

Schedule: July 6 18:00-18:30 Room 436

Wilfried Kenmoe Nzali

Weierstrass Institute for Applied Analysis and Stochastics(WIAS-Berlin), Germany

Co-Author(s): Christian Bayer ,Doerte Kreher , Manuel Landstorfer

Abstract:

attery energy storage systems are increasingly used in volatile electricity markets where aggressive cycling can increase economic returns but also speed up degradation. One important source of capacity loss is the growth of the solid electrolyte interphase layer which affects long term performance. This work presents an optimal control framework that includes both market price uncertainty and a physics based model of this degradation process. The model is placed inside a stochastic optimization problem that selects charge and discharge actions while protecting battery health. Numerical tests show how market volatility, the growth of the interphase layer, and operational limits influence the resulting strategies.

Filippov's Theorem for stochastic differential inclusions driven by semimartingales

Schedule: July 6 14:30-15:00 Room 436

Mariusz Michta

Institute of Mathematics, University of Zielona Gora, Poland

Co-Author(s): Mariusz Michta

Abstract:

In the talk, we present a stochastic version of Filippov's Theorem and its application to the qualitative analysis of stochastic differential inclusions with respect to semimartingale integrators. Based on this result, in particular, we establish the Lipschitz dependence of the solution set of the considered inclusion on initial sets, and continuous dependence on the multivalued operators and the integrators involved. We also provide analogous continuity properties for the attainable sets generated by the solutions of the given inclusion.

Deep gradient flow methods for PDEs and applications in finance

Schedule: July 7 8:00-8:30 Room 436

Antonis Papapantoleon

TU Delft, Netherlands

Co-Author(s): Chenguang Liu; Emmanuil Georgoulis; Jasper Rou; Costas Smaragdakis

Abstract:

We develop a novel deep learning approach for pricing European options in diffusion and jump-diffusion models, that can efficiently handle high-dimensional problems resulting from Markovian approximations of rough volatility models or from multi-asset options. The option pricing partial differential equation is reformulated as an energy minimization problem, which is approximated in a time-stepping fashion by deep artificial neural networks. The proposed scheme respects the asymptotic behavior of option prices for large levels of moneyness and adheres to a priori known bounds for option prices. The accuracy and efficiency of the proposed method is assessed in a series of numerical examples, with particular focus in the lifted Heston model and the multi-variate Merton model. Time permitting, theoretical results about the generalization error of this method will be discussed.

Stability analysis of a branching diffusion solver for semilinear heat equations

Schedule: July 7 14:00-14:30 Room 436

Nicolas Privault

Nanyang Technological University, Singapore

Co-Author(s): Qiao Huang and Nicolas Privault

Abstract:

Stochastic branching algorithms provide a useful alternative to grid-based schemes for the numerical solution of partial differential equations, particularly in high-dimensional settings. However, they require a strict control of the integrability of random functionals of branching processes in order to ensure the non-explosion of solutions. In this paper, we study the stability of a functional branching representation of PDE solutions by deriving sufficient criteria for the integrability of the multiplicative weighted progeny of stochastic branching processes. We also prove the uniqueness of mild solutions under uniform integrability assumptions on random functionals.

Asymptotic behaviors of small perturbation for path-dependent multivalued McKean-Vlasov stochastic differential equations

Schedule: July 7 14:30-15:00 Room 436

Huijie Qiao

Southeast University, Peoples Rep of China

Co-Author(s): Ying Ma

Abstract:

In this talk I will introduce the asymptotic behavior of path-dependent multivalued McKean-Vlasov stochastic differential equations perturbed by small noise. Specifically, we first establish a large deviation principle for such equations under non-Lipschitz coefficients by the weak convergence approach. Subsequently, we introduce an auxiliary equation and apply it to derive the moderate deviation principle.

Optimal Energy Management via Extended McKean-Vlasov Stochastic Control; a Lagrange Relaxation formulation

Schedule: July 7 17:00-17:30 Room 436

Riccardo Saporiti

EPFL, Switzerland

Co-Author(s): Fabio Nobile, Raul Tempone

Abstract:

In this talk, we present a framework for tackling Stochastic Optimal Control Problems of Extended McKean-Vlasov type, which are characterized by scalar interactions with respect to the laws of the state and control variables. We employ a continuous-time Lagrangian relaxation that transforms the original extended McKean-Vlasov control problem into a saddle-point problem, where the inner minimization represents a standard stochastic optimal control problem in the physical state space. We derive a Hamilton-Jacobi-Bellman (HJB) equation on the state space by applying the traditional Bellman principle of optimality, which provides optimality conditions for the control variable. To tackle the resulting relaxed problem and the associated HJB equation, we resort to gradient-based methods along with semi-implicit partial differential equation solvers. As a specific application, we focus on the energy sector, particularly on the optimal scheduling of the day-ahead dispatch plan for an aggregated consumer that manages its smart grid. An innovative, Neural Network-based, Markovian projection is proposed to reduce the dimensionality of the state space by condensing the uncontrolled residual consumption into a single stochastic process. Numerical results validate the framework we presented.

Generative Market Equilibrium Models with Stable Adversarial Learning via Reinforcement Link

Schedule: July 7 15:30-16:00 Room 436

Xiaofei Shi

University of Toronto, Canada

Co-Author(s): Anastasis Kratsios, Qiang Sun, Zhanhao Zhang

Abstract:

We present a general computational framework for solving continuous-time financial market equilibria under minimal modeling assumptions while incorporating realistic financial frictions, such as trading costs, and supporting multiple interacting agents. Inspired by generative adversarial networks (GANs), our approach employs a novel generative deep reinforcement learning framework with a decoupling feedback system embedded in the adversarial training loop, which we term as the reinforcement link. This architecture stabilizes the training dynamics by incorporating feedback from the discriminator. Our theoretically guided feedback mechanism enables the decoupling of the equilibrium system, overcoming challenges that hinder conventional numerical algorithms. Experimentally, our algorithm not only learns but also provides testable predictions on how asset returns and volatilities emerge from the endogenous trading behavior of market participants, where traditional analytical methods fall short. The design of our model is further supported by an approximation guarantee.

A two-step stochastic model of anaerobic digestion and opportunities for biogas production

Schedule: July 7 9:00-9:30 Room 436

Calvin Tadmon

University of Dschang, Cameroon

Abstract:

In this talk, we consider the so-called deterministic anaerobic digestion model number 2, derive its stochastic version by perturbing the maximal growth rate of acidogenic microorganisms with a white noise, and investigate the global dynamics of the stochastic model obtained. By mainly relying on *Itô* formula, combined with other tools from stochastic analysis, we first prove the existence and uniqueness of a global positive strong solution of the stochastic model. Then, we explore and derive the conditions of persistence and extinction of the microorganisms. Finally, by performing some numerical simulations, we illustrate the theoretical results obtained. In some cases, the interpretation of the results enables clarification of conditions under which biogas can be produced.

Optimal Market-Making with Hawkes Process: A Markovian Approximation Approach via Mercer's Expansion

Schedule: July 6 15:30-16:00 Room 436

Alex Tse

University College London, England

Co-Author(s): Nicholas Martin

Abstract:

We study an optimal market-making problem under which the order flow and liquidity level are driven by self-exciting Hawkes processes. To overcome the challenge brought by the non-Markovian structure of the problem, we propose a Markovian lifting approach where the Hawkes kernels are approximated by their truncated Mercer's expansions. This enables dynamic programming and in turn computationally feasible procedures to solve the market-making problem. The theoretical convergence of the approximated solution to the true value function is proven. Our numerical findings show that ignoring persistence with the the order flow and liquidity level underestimates adverse selection risk, whereas explicitly modelling them improves the robustness and profitability of the market-making strategies.

Optimality and Robustness in Path-Planning Under Initial Uncertainty

Schedule: July 7 16:30-17:00 Room 436

Alexander Vladimirovsky

Cornell University, USA

Co-Author(s): Dongping Qi and Adam Dhillon

Abstract:

Classical deterministic optimal control problems assume full information about the controlled process. The theory of control for general partially-observable processes is powerful, but the methods are computationally expensive and typically address the problems with stochastic dynamics and continuous (directly unobserved) stochastic perturbations. In this presentation we focus on path planning problems which are in between -- deterministic, but with an initial uncertainty on either the target or the running cost on parts of the domain. That uncertainty is later removed at some time T , and the goal is to choose the optimal trajectory until then. We address this challenge for three different models of information acquisition: with fixed T , discretely distributed and exponentially distributed random T . We develop models and numerical methods suitable for multiple notions of optimality: based on the average-case performance, the worst-case performance, the average constrained by the worst, the average performance with probabilistic constraints on the bad outcomes, risk-sensitivity, and distributional-robustness. We illustrate our approach using examples of pursuing random targets identified at a (possibly random) later time T .

Time-Inconsistent Stochastic Optimal Control Problems in Infinite Time Horizon

Schedule: July 6 14:00-14:30 Room 436

Qingmeng Wei

Northeast Normal University, Peoples Rep of China

Co-Author(s): Jiongmin Yong

Abstract:

This talk is concerned with a time-inconsistent stochastic optimal control problem in an infinite time horizon with a non-degenerate diffusion in the state equation. A major assumption is that people become rational after a large time. Under such a condition, the problem is decomposed into two parts: a non-autonomous time-consistent problem in infinite time horizon and a time-inconsistent problem in infinite time horizon. Then an equilibrium strategy will be constructed. Both Bolza type problem and recursive cost problem are considered.

Continuous-time reinforcement learning for optimal switching over multiple regimes

Schedule: July 6 16:30-17:00 Room 436

Xiang Yu

The Hong Kong Polytechnic University, Hong Kong

Co-Author(s): Yijie Huang, Mengge Li, Zhou Zhou

Abstract:

This paper studies the continuous-time reinforcement learning (RL) for optimal switching problems across multiple regimes. We consider a type of exploratory formulation under entropy regularization where the agent randomizes both the timing of switches and the selection of regimes through the generator matrix of an associated continuous-time finite-state Markov chain. We establish the well-posedness of the associated system of Hamilton-Jacobi-Bellman (HJB) equations and provide a characterization of the optimal policy. The policy improvement and the convergence of the policy iterations are rigorously established by analyzing the system of equations. We also show the convergence of the value function in the exploratory formulation towards the value function in the classical formulation as the temperature parameter vanishes. Finally, a reinforcement learning algorithm is devised and implemented by invoking the policy evaluation based on the martingale characterization. Our numerical examples with the aid of neural networks illustrate the effectiveness of the proposed RL algorithm.

Stochastic Differential Games with Random Coefficients and Stochastic Hamilton-Jacobi-Bellman-Isaacs Equations

Schedule: July 6 13:30-14:00 Room 436

Jing Zhang

Fudan University, Peoples Rep of China

Abstract:

We study a class of zero-sum two-player stochastic differential games with the controlled stochastic differential equations and the payoff/cost functionals of recursive type. As opposed to the pioneering work by Fleming and Souganidis [Indiana Univ. Math. J., 38 (1989), pp. 293--314] and the seminal work by Buckdahn and Li [SIAM J. Control Optim., 47 (2008), pp. 444--475], the involved coefficients may be random, going beyond the Markovian framework and leading to the random upper and lower value functions. We first prove the dynamic programming principle for the game, and then under the standard Lipschitz continuity assumptions on the coefficients, the upper and lower value functions are shown to be the viscosity solutions of the upper and the lower fully nonlinear stochastic Hamilton-Jacobi-Bellman-Isaacs (HJBI) equations, respectively. A stability property of viscosity solutions is also proved. Under certain additional regularity assumptions on the diffusion coefficient, the uniqueness of the viscosity solution is addressed as well.

Second-order PDEs on Wasserstein Space

Schedule: July 6 15:00-15:30 Room 436

Xin Zhang

NYU, USA

Co-Author(s): Erhan Bayraktar, Ibrahim Ekren, and Xihao He.

Abstract:

Mean-field control with common noise and filtering problems naturally lead to second-order PDEs on Wasserstein space. In this talk, we analyze a class of such equations in which the second-order operator is finite-dimensional in nature. We establish comparison principles and apply them to obtain particle convergence rates in mean-field control. The talk is based on joint work with Erhan Bayraktar, Ibrahim Ekren, and Xihao He.

Long-Term Average Impulse Control with Mean Field Interactions

Schedule: July 7 8:30-9:00 Room 436

Chao Zhu

University of Wisconsin-Milwaukee, USA

Abstract:

This paper analyzes and explicitly solves a class of long-term average impulse control problems with a specific mean-field interaction. The underlying process is a general one-dimensional diffusion with appropriate boundary behavior. The model is motivated by applications such the optimal long-term management of renewable natural resources and financial portfolio management. Each individual agent seeks to maximize her long-term average reward, which consists of a running reward and income from discrete impulses, where the unit intervention price depends on the market through a stationary supply rate, the specific mean field variable to be considered. In a competitive market setting, we establish the existence of and explicitly characterize an equilibrium strategy within a large class of policies under mild conditions. Additionally, we formulate and solve the mean field control problem, in which agents cooperate with each other, aiming to realize a common maximal long-term average profit. To illustrate the theoretical results, we examine a stochastic logistic growth model and a population growth model in a stochastic environment with impulse control.

Special Session 39 : Recent Developments in Gradient Flows: Theory, Numerics, and Applications

Organizer(s): Chaoyu Quan , Xiaoming Wang , Jiang Yang

Introduction: Gradient flows play a fundamental role in modeling dissipative evolution in various scientific and engineering disciplines. Recent advancements have significantly enhanced the theoretical understanding, numerical analysis, and practical applications of these flows. This special session will focus on cutting-edge developments for gradient flows, including theoretical analysis, structure-preserving discretizations, variational approaches, and machine-learning-assisted solvers. Topics of interest include, but are not limited to, energy-stable schemes, adaptive algorithms, optimization techniques, and their applications in fluid dynamics, material sciences, and image processing. A particular emphasis will be placed on novel numerical frameworks that ensure stability, efficiency, and accuracy, addressing key challenges in high-dimensional and complex systems. By bringing together experts from diverse backgrounds, this session aims to foster discussions on emerging trends and future directions in computational methods for gradient flows. We welcome contributions from both theoretical and applied perspectives to advance the numerical treatment of these important mathematical models.

Dynamics in some phase field models

Schedule: July 8 15:00-15:30 Room 301

Yuan Chen

Chinese University of Hong Kong(Shenzhen), Peoples Rep of China

Abstract:

In this talk, I will introduce some dynamics arising from some phase field models. Theoretical mathematical analysis including sharp interface limit and existence of solutions will be presented.

Adaptive time-stepping and maximum-principle-preserving flow dynamic approach for gradient flows

Schedule: July 8 14:00-14:30 Room 301

Qing Cheng

Tongji University, Peoples Rep of China

Co-Author(s): Qianqian Liu, Wenbin Chen, Jie Shen

Abstract:

We develop an adaptive time-stepping approach for gradient flows with distinct treatments for conservative and non-conservative dynamics. For the non-conservative gradient flows in Lagrangian coordinates, we propose a modified formulation augmented by auxiliary terms to guarantee positivity of the determinant, and prove that the corresponding adaptive second-order Backward Difference Formulas (BDF2) scheme preserves energy stability and the maximum principle under suitable time-step ratio constraint.

Super-convergent HDG methods for the Cahn-Hilliard equation

Schedule: July 8 16:30-17:00 Room 301

Daozhi Han

State University of New York at Buffalo, USA

Co-Author(s): Gang Chen, Jiaxuan Liu, John Singler, Yangwen Zhang, Dujin Zuo

Abstract:

We present and analyze a super-convergent hybridizable discontinuous Galerkin method for solving the Cahn-Hilliard equation. The HDG method utilizes polynomials of degree $k+1$ for scalar variables and polynomials of degree k for fluxes and numerical traces with reduced diffusion stabilization. For the classical Cahn-Hilliard equation we establish optimal convergence rates for all variables and all polynomial orders with error constants depending on the inverse of interface thickness in polynomial orders. For the advective Cahn-Hilliard equation we show that optimal convergence can be obtained without any advection stabilization. The key tools involved include the HDG spectral estimate of the linearized Cahn-Hilliard operator and new elliptic projection adapted to advection.

A gradient flow model for ground state calculations in wigner formalism based on density functional theory

Schedule: July 8 9:30-10:00 Room 301

Guanghui Hu

University of Macau, Macau

Co-Author(s): Li Ruo; Zhan Hongfei

Abstract:

In this talk, a gradient flow model is presented for conducting ground state calculations in the Wigner formalism of many-body systems in the framework of density functional theory. Theoretically, an energy functional in the Wigner formalism is proposed, based on which the minimization problem is designed and analyzed for the ground state, providing a new perspective for ground state calculations of the Wigner function. Employing density functional theory, a gradient flow model is built upon the energy functional to obtain the ground state Wigner function representing the entire many-body system. Numerically, a parallelizable algorithm is developed using the operator splitting method and Fourier spectral collocation method. Numerical experiments demonstrated the anticipated accuracy, encompassing the one-dimensional system with upto 2^{21} particles and the three dimensional system with defect, showcasing the potential of our approach towards the large scale simulations.

A generalized SAV approach for nonlinear dissipative systems

Schedule: July 8 14:30-15:00 Room 301

Fukeng Huang

Eastern Institute of Technology, Ningbo, Peoples Rep of China

Abstract:

In this talk, I will present the generalized SAV approach, which possessed the following attractive properties: 1) It yields a long time uniform upper bound for the numerical solutions unconditionally; 2) It is applicable to general dissipative systems, not limited to gradient flow systems; 3) It enables the construction of arbitrarily high-order schemes with low computational cost. As an application, we construct the longtime stable schemes for the forced Navier-Stokes equations. Numerical examples will be presented to demonstrate the advantages of our approach.

The Cahn-Hilliard equation with a source term

Schedule: July 8 9:00-9:30 Room 301

Alain Miranville

University Le Havre Normandie, France

Abstract:

Our aim in this talk is to discuss the Cahn-Hilliard equation with a (nonlinear) source term and a logarithmic nonlinear term. Such an equation has applications in, e.g., tumor growth and image processing. In particular, we discuss the existence of weak solutions and their regularity.

Mixed finite element methods for biharmonic obstacle problems

Schedule: July 8 15:30-16:00 Room 301

Paolo Piersanti

The Chinese University of Hong Kong, Shenzhen, Peoples Rep of China

Co-Author(s): Tianyu Sun

Abstract:

This talk introduces a mixed Finite Element Method aimed at approximating solutions to fourth-order variational problems with constraints. We first address the biharmonic obstacle problem and propose an error convergence framework that offers an alternative to the established approaches by Ciarlet & Raviart and Ciarlet & Glowinski. Our method emphasises improved ease of numerical implementation, which may enhance practical usability. Next, we investigate a two-dimensional variational problem involving linearly elastic shallow shells constrained within a specified half-space. We begin with cases where the middle surface has non-zero curvature and demonstrate that applying a mixed Finite Element Method with conforming elements requires a symmetry constraint on the gradient matrix of the dual variable. Notably, we find that this implementation cannot rely solely on Courant triangles, indicating a variation in approach based on the geometric features of the problem. This constitutes a counterexample to the statement that solutions of fourth order linear problems can be approximated by solely resorting to Courant triangles if one considers the mixed formulation of the original problem. We notice that this counterexample arises in connection with the lack of rigidity of linearly elastic shallow shells middle surface. In cases where the middle surface is flat, we observe that the symmetry constraint is not necessary, allowing for the use of Courant triangles alone for solution approximation. This observation suggests that shell geometry can significantly influence the selection of Finite Element methods for discretization. Our theoretical findings are supported by a series of supplementary numerical experiments, illustrating the practicality of the proposed methods.

Structure-preserving compact splitting methods for Schrödinger-type equations

Schedule: July 8 13:30-14:00 Room 301

Jie Shen

Eastern Institute of Technology, Ningbo, Peoples Rep of China

Abstract:

We develop a novel class of high-order, structure-preserving methods for Schrödinger-type equations based on a predictor-corrector framework that integrates operator splitting with Lagrange multiplier corrections. The predictor employs high-order compact splitting spectral methods, in which the Hamiltonian is decomposed into two parts that are exactly solvable in either phase or physical space, while the corrector enforces the exact preservation of multiple invariants through Lagrange multipliers. We rigorously prove the existence and uniqueness of the Lagrange multipliers under reasonable conditions, and show that the overall scheme retains the same temporal order as the underlying predictor. The resulting schemes constitute the first class of split-type schemes capable of preserving multiple original invariants, and they demonstrate markedly improved long-time accuracy and stability compared to classical splitting approaches. Numerical experiments validate the theoretical findings and illustrate the effectiveness of the proposed methods for rotating dipolar Bose-Einstein condensates with two invariants and rotating spin-1 systems with three invariants. More broadly, the proposed framework provides a simple and general strategy for systematically transforming existing time integrators into structure-preserving methods for Hamiltonian systems

High-order energy stable numerical schemes for gradient flows

Schedule: July 8 17:00-17:30 Room 301

Xiaoming Wang

Eastern Institute of Technology, Peoples Rep of China

Co-Author(s): Wenbin Chen, Zhaohui Fu, Haifeng Wang, Shufeng Wang

Abstract:

We present several high-order energy stable numerical schemes for gradient flows by combining exponential time differencing with either multi-step (MS) or Runge-Kutta (RK) method. All schemes are variable-step and unconditionally stable. Numerical experiments demonstrate the effectiveness of these schemes in both fixed-step and adaptive-step setting.

Adaptive feature capture method for solving partial differential equations with near singular solutions

Schedule: July 8 8:30-9:00 Room 301

Xiaoping Wang

The Chinese University of Hong Kong (Shenzhen) /Shenzhen International Center for Industrial and Applied Mathematics,
Peoples Rep of China

Co-Author(s): Xiaoping Wang

Abstract:

We propose the Adaptive Feature Capture Method (AFCM), a novel machine learning framework that adaptively redistributes neurons and collocation points in high gradient regions to enhance local expressive power. AFCM employs the gradient norm of an approximate solution as a monitor function to guide the reinitialization of feature function parameters. This ensures that partition hyperplanes and collocation points cluster where they are most needed, achieving higher resolution without increasing computational overhead.

Special Session 40 : Applications of dynamical systems in medicine and biology

Organizer(s): Beata Jackowska-Zduniak , Urszula Forys

Introduction: Dynamical systems provide a powerful framework for understanding complex temporal behaviors in biological and medical processes. This session brings together recent advances in the modeling, analysing, and simulating systems arising in physiology, epidemiology, oncology, and population dynamics. By leveraging tools from nonlinear dynamics, bifurcation theory, and stability analysis, we aim to uncover mechanisms that govern pattern formation, disease progression, and treatment response. Presentations will explore continuous and discrete models, including delay differential equations, reaction-diffusion systems, and structured population models. Special emphasis will be placed on the interplay between mathematical theory and empirical data, with contributions demonstrating how rigorous analysis can inform clinical decisions or experimental design. Topics may include tumor-immune interactions, heart disease, viral dynamics, tissue engineering, neural activity, or ecological networks. This session provides a platform for interdisciplinary dialogue between mathematicians and life scientists, intending to foster new collaborations and methodologies. We encourage contributions that bridge scales—from molecular to population levels—or introduce innovative mathematical approaches to biological questions.

Cardiomyocyte Dynamics: From Low Dimensional To Realistic Models

Schedule: July 7 8:00-8:30 Room 433

Roberto Barrio

University of Zaragoza, Spain

Co-Author(s): R. Barrio, H. Kitajima, M.A. Martinez, S. Serrano

Abstract:

Early afterdepolarizations (EADs) are abnormal behaviors that can lead to heart failure and even cardiac death. In this presentation, we review recent results and we mathematically investigate the occurrence and development of these phenomena in two realistic ventricular myocyte models: the rabbit model of Sato (2009) and the human model of O'Hara (2011). These models are of high dimension, 27 and 41 respectively, so a mix of techniques must be used in their study. We connect the results with a reduced low-dimensional model, the Luo-Rudy cardiomyocyte model (1991). The combined use of analytical and numerical techniques allows us to propose a global conjecture of a mathematical mechanism of EAD creation in low- and high-dimensional models. By examining the bifurcation structure of the model, we elucidate the dynamical elements associated with these patterns and their transitions. Using a fast-slow analysis, we explore the emergence and evolution of EAD in the low-dimensional model and develop new methodologies for fast-slow decomposition for the realistic high-dimensional O'Hara model. This decomposition has allowed us to propose some new theoretical techniques for the control of prearrhythmia situations.

Fast inference for multivariate evolutionary dynamics

Schedule: July 7 13:30-14:00 Room 433

Krzysztof J. Bartoszek

Department of Computer and Information Science, Linköping University, Sweden

Co-Author(s): Krzysztof Bartoszek

Abstract:

Co-adaptation is key to understanding species evolution as different traits have to be coordinated. We have been developing fast calculation R packages (bgphy, glinvc, mvSLOUCH, pcmabc, PCMBase, PCMFIt) that are able to handle general, multivariate, Gaussian, branching evolutionary dynamics. I will discuss setting up different hypotheses, consequences of measurement error, errorsome model selection, and asymptotic results that allow for improved choice of seeds for numerical procedures. The talk will be illustrated with relationships between traits in ungulates, in the genus *Ferula* (Apiaceae), in angiosperms, and carnivorans.

A Mathematical Model of CAR T Cell Therapy: How B Cell Influx Shapes Leukemia Outcomes

Schedule: July 6 13:30-14:00 Room 433

Juan Belmonte Beitia

UCLM, Spain

Co-Author(s): Marek Bodnar, Monika J. Piotrowska, Sergio Perez Luque

Abstract:

Chimeric Antigen Receptor (CAR) T cell therapy has shown remarkable success in treating B cell malignancies, yet the long term dynamics of CAR T cells, tumor cells, and healthy B cells remain incompletely understood. We present a mathematical model of CAR T cell therapy for leukemia that incorporates a constant influx of healthy B cells from the bone marrow, a source term previously neglected, as well as CAR T cell inactivation by tumor cells. The model is analyzed as a system of nonlinear ordinary differential equations. We characterize the existence, uniqueness, and local and global stability of steady states, revealing how the interplay between CAR T cell activation and tumor burden determines outcomes such as remission or relapse. Bifurcation analysis identifies critical thresholds for treatment success. For periodic treatment protocols, we prove the existence of periodic solutions and derive conditions for tumor eradication. Additionally, we analyze an impulsive treatment regimen and obtain criteria for local stability of tumor free periodic solutions. Our results highlight the dual role of healthy B cells in sustaining CAR T cell activity and provide a theoretical framework for optimizing treatment strategies.

An impact of B-cells dynamics on CAR-T cell therapy for glioblastoma

Schedule: July 6 14:00-14:30 Room 433

Marek Bodnar

Institute of Applied Mathematics, University of Warsaw, Poland

Co-Author(s): Monika J. Piotrowska, Eryk Werens, Juan Belmonte-Beitia

Abstract:

CAR-T cell immunotherapy involves the genetic reprogramming of T-lymphocytes to recognize and engage cancer cells, thereby triggering an anti-tumour immune response. While this treatment has been approved for hematological malignancies, its application to solid tumours presents significant new obstacles. These challenges include the heterogeneity of antigen expression, the presence of antigen-positive non-tumoural cells, immune inhibitory molecules, and the limited trafficking of CAR-T cells within the complex tumour microenvironment. In this talk, we explore a modification of the model introduced by Bodnar et al. (Nonlinear Dynamics, 2025). The original model neglected the production of B-cells; here, we extend the framework by incorporating appropriate terms to account for their dynamics. The resulting system of two ordinary differential equations describes the interaction between CAR-T cells in the blood and B-cells, which in turn influences the dynamics of both tumour cells and CAR-T cells in the brain. We present stability analyses for the system under both constant and impulsive treatment regimens, accounting for the external influx of both CAR-T and B-cells.

A two-strain dengue model with a constant recruitment rate

Schedule: July 6 17:00-17:30 Room 433

Marcin Choinski

Institute of Information Technology, Warsaw University of Life Sciences - SGGW, Poland

Co-Author(s): Joanna Renclawowicz, Urszula Skwara

Abstract:

We propose a two-strain dengue model that captures the interactions between human and mosquito populations. It incorporates vertical transmission of the dengue virus from adult mosquitoes to their offspring, along with a constant recruitment rate of susceptible larval mosquitoes. We discuss the existence and local stability of the disease-free and one-strain equilibria. Moreover, we indicate stationary states with two strains. Analytical outcomes are complemented with numerical simulations.

Mathematical modelling of epithelial-mesenchymal transitions

Schedule: July 6 14:30-15:00 Room 433

Urszula Forys

University of Warsaw, Faculty of Mathematics, Informatics and Mechanics, Poland

Co-Author(s): Magdalena Szafranska-Leczycka

Abstract:

Epithelial-to-Mesenchymal Transition and its reverse, Mesenchymal-to-Epithelial Transition, are important biological processes influencing cancer progression, in particular tumor invasiveness and metastasis. Based on Celi-Terrassa et al. (2018), we propose a mathematical model describing interactions between main components of these transitions, taking into account: initiation of TGF- β signaling, the miR-200/ZEB feedback loop, and E-cadherin expression, which is a marker of the epithelial phenotype. In my talk I will present the scheme of the model and the basic dynamics of its two main subsystems: the first one describing TGF- β in its free and bound forms, and the other one describing production and degradation of miR-200, ZEB and E-cadherin. The main feature of the second subsystem is the possibility of bistability and hysteresis, which is dependent on the level of TGF- β flowing there. I will focus mainly on that aspect on the presented model.

Impact of Aging on Pacemaker Cell Electrophysiology: A Maltsev-Lakatta Modeling Study

Schedule: July 7 8:30-9:00 Room 433

Beata Jackowska-Zduniak

Gdańsk University of Technology, Poland

Abstract:

Aging of the sinoatrial node (SAN) is associated with progressive alterations in ionic currents and intracellular calcium dynamics, leading to impaired cardiac automaticity. In this study, we investigate the effects of aging at the level of a single pacemaker cell using the Maltsev-Lakatta model, in which rhythmic activity emerges from the interaction between the membrane clock and the calcium clock. Aging is represented as a gradual modulation of system parameters, in particular a reduction of the I_f current, attenuation of the L-type calcium current (I_{CaL}), and weakening of the coupling between intracellular calcium cycling and the Na^+-Ca^{2+} exchanger (NCX). Numerical simulations indicate that age-related parameter drift leads to a prolongation of the cycle length, reduced stability of oscillations, and increased sensitivity of the system to perturbations. The proposed approach provides a foundation for future multiscale analyses.

Regulatory Networks In The Life Sciences: Rule-Based And Data-Driven Modeling

Schedule: July 7 14:00-14:30 Room 433

Markus A Kirkilionis

University of Warwick, British Virgin Islands

Co-Author(s): n/a

Abstract:

Life itself is a kind of wise tautology, it is there because it can be. The matter our life consists of, as created by the evolution of the universe, just has the right elements and molecules that with their constant recombination, can take over higher-order functions, like delivering a memory established in the genetic code, or a metabolism counteracting the overall increase of entropy in the wider cosmic environment. Once memory and activity achieved by energy storage are possible, the evolution of life on this planet was possible. New higher order functions are invented by evolution, creating new complexities, like functioning, i.e. relatively stable ecosystems thriving on stable matter and energy availability. Eventually human evolution created new regulatory networks, societies with their economies. Coupling all these regulatory networks together leads eventually to the planetary system, which also can be healthy or not, like single organisms or ecosystems, depending on their stability properties. In this contribution we ask ourselves whether there are universal principles such regulatory networks must possess in order to achieve the function they are either possessing by ancient evolutionary trials, or by novel, perhaps artificial construction. We must first be able to describe such systems. Here the suggestion is to look at rule-based systems, based on reaction kinetics, as a universal approach. This will eventually include descriptions as dynamical systems, but also as stochastic processes if necessary. Next we ask whether there are theories which from the set of all possible regulatory networks can determine the ones which are stable according to some stability criterion. Note that equilibrium, or total balance, is just one such stability concept, but perhaps the most important one. Then we are asking whether, once we have a language to describe all regulatory networks, whether there is a way to automatically select a network which best fits measured data. This is the domain of data-driven modelling, at which we will look at in an overview.

On Observability of Limit Cycles in the Chemostat

Schedule: July 7 14:30-15:00 Room 433

Torsten A Lindström

Linnaeus University, Sweden

Co-Author(s): Torsten Lindström

Abstract:

Ever since May (Science, 1974) pointed out that the dynamics of equations describing commonly appearing equations in ecology contains the seeds of chaos and nonlinear dynamics, it has been a debate whether nonlinear dynamics and chaos actually can be observed in ecological systems. The chemostat is a very basic experimental setting describing of an ecosystem with an explicitly modelled resource flow. Presence of autonomous limit cycles is the simplest nonlinear dynamical phenomenon that can be studied and the Rosenzweig and MacArthur (Am. Nat. 1963) criterion divides the parameter space of the deterministic two-species chemostat into a one regime describing global stability and one with autonomous limit cycles. Deterministic systems of differential equations can, however, only be viewed only as approximations of the Markov processes describing the ecological phenomena (Renshaw, Stochastic Population Processes, 2011). It is likely that deterministic stable equilibria describing sufficiently large populations are described by approximately normal distributions and this can indeed, be proved in the univariate case. The objective of this talk is to study in what sense limit cycles approximate the quasi-stationary distributions arising in the Markov process describing the two-species chemostat.

Distances on DNA sequences

Schedule: July 6 18:00-18:30 Room 433

Magdalena Nowak

Jan Kochanowski University of Kielce, Poland

Co-Author(s): Taras Banakh, Judyta Błak, Grzegorz Czerwonka, Joanna Garbulińska-Węgrzyn, Piotr Lisicki, Michał Popławski

Abstract:

We introduce several distances based on the Chaos Game Representation method. We use the pseudometric d_k counting the differences in the number of corresponding k -mers in two DNA sequences g, g' , to define a metric $d(g, g') = \sum_{k=1}^{\infty} \frac{d_k(g, g')}{2^k}$ which combines the analysis of the frequency of occurrence of all possible k -mers. We compare this approach with known genetic distances such as Levenshtein edit distance, Average Nucleotide Identity or Mash distance. We also introduce distances invariant under the operations of inversion or nucleotides complementarity.

Mathematical Tools Combined with Neural CDE for prediction of Alzheimer diseases

Schedule: July 7 9:30-10:00 Room 433

Andrzej Nowakowski

University of Lodz, Poland

Co-Author(s): Anita Krawczyk

Abstract:

The existing AI agents can do many actions, however, it seems that we still have problems with control and prediction next steps in time series. Our aim in this article, being in the spirit of machine learning, extends the applicability of neural ordinary differential equation (Neural CDE), described in \cite{FLN} for neural network modeled by an ordinary differential equations to a case of a mathematical model given by a system of partial differential equations (PDE). That requires new approach for prediction the next step in the given time series. In order to apply Neural CDE methodology we transform our system of PDE (modeling mathematically Alzheimer) to a new system of ODE. It is possible because we can treat an ANN as a function which in turn for a given set of weights determines a point in this space, and learning algorithms differ in the way they traverse it. We replace this space with a family of functions (family of solutions) which conforms well defined mathematical conditions. This allows us to develop an optimal control approach, parameterized by a set of controls and defined as neural controlled differential equations (Neural CDE). Thus we turn the difficult to explain artificial neural network learning process into a well-posed mathematical problem and apply to it a dual dynamic programming idea to formulate an optimization problem subject to Neural CDE. Turning the problem into optimal control problem allows one to define it in a rigorous way; however, it does not say much about the way it may be solved. To overcome theoretical difficulties and solve it in satisfactory and applicable way (our goal is to propose general methodology which is both theoretically correct and practically applicable to various tasks), we follow the methodology of the dual dynamic programming to derive the sufficient optimality conditions in the form of verification theorem and that simplify all practical considerations. We provide and prove verification conditions that should correctly predict the next step in time series. To show applicability of the presented theory we adopt state-of-the-art mathematical model of the Alzheimer disease for Neural CDE to predict state of the disease after 10, 20 years.

Targeted Control of Multidrug-Resistant Bacteria in Healthcare Networks

Schedule: July 6 16:30-17:00 Room 433

Monika J Piotrowska

University of Warsaw, Poland

Co-Author(s): Monika Joanna Piotrowska, Konrad Sakowski, Agata Lonc, Mirjam E. Kretzschmar, Andre Karch, Johannes Horn, Rafael Mikolajczyk

Abstract:

We present a mathematical framework for modelling patient colonisation by multidrug-resistant bacteria across a healthcare system structured as a network of care units. The model incorporates patient movements between units, including direct hospital-to-hospital transfers and indirect transfers via home stays. Patients are stratified into three groups: low-risk, high-risk, and rare one-time visitors. Using this framework, we evaluate the effectiveness of targeted intervention strategies designed to reduce colonisation levels within the network. Interventions can be directed at specific patient groups or applied selectively in chosen care units. Each strategy is also assessed in terms of the costs it generates, allowing comparison of both epidemiological impact and resource use. The model is informed and calibrated using real-world patient movement data, enabling realistic evaluation of potential outcomes. By accounting for patient heterogeneity, movement patterns, and cost-effectiveness, the framework provides a flexible and practical tool for optimising infection control strategies in interconnected healthcare settings. This approach supports data-driven decision-making for managing multidrug-resistant bacteria while balancing intervention efficiency and resource allocation.

Co-infection model of airborne disease with two-strain dengue.

Schedule: July 6 17:30-18:00 Room 433

Joanna Rencawowicz

Institute of Mathematics and Cryptology, Cybernetics Faculty, Military University of Technology, Poland

Co-Author(s): Marcin Choiński

Abstract:

In this talk we propose a model describing the co-infection spread of airborne disease and dengue. We introduce an unusual approach that combines airborne disease with a relatively deep insight into dengue dynamics. We consider two distinct dengue strains that cause primary and secondary infections, which can yield antibody-dependent enhancement. Moreover, we incorporate vertical transmission into a mosquito population. Such an assumption provides a complex system for which we can provide analytical results. Thus, we prove the existence of stationary states across various epidemic scenarios and determine local stability for some states. Additionally, we conduct numerical simulations related to a real case of airborne disease and dengue spread in Latin America. The simulations confirm our established mathematical outcomes.

Dynamics of 2D hybrid non-autonomous neuron models with dynamical threshold

Schedule: July 7 9:00-9:30 Room 433

Justyna Signerska

Gdansk University of Technology, Poland

Co-Author(s): Piotr Bartłomiejczyk, Juan Belmonte Beitia

Abstract:

We investigate a class of two-dimensional hybrid non-autonomous neuron models with a dynamical threshold, focusing on the interplay between continuous subthreshold dynamics and discrete reset mechanisms. The model consists of a linear voltage equation coupled with a threshold variable evolving according to a nonlinear function of the voltage, and incorporates periodic external input in the form of either pulse or rectified sinusoidal currents. In particular, we study periodic solutions of the system and prove the existence and uniqueness of a globally attracting periodic orbit in the non-hybrid case and show that the hybrid system admits at most one reset-free periodic orbit, while numerical evidence suggests the possible coexistence of reset-free and resetting periodic attractors. These results provide a rigorous mathematical framework for understanding dynamical threshold mechanisms in neuron models and contribute to the theoretical characterization of spiking versus non-spiking behavior under time-dependent forcing.

A little bit about math models for drug concentration in the body

Schedule: July 7 15:00-15:30 Room 433

Jacson Simsen

Institute of Mathematics and Computing, Federal University of Itajubá, Brazil, Brazil

Co-Author(s): Jacson Simsen

Abstract:

Title: A little bit about math models for drug concentration in the body Jacson Simsen-IMC-UNIFEI - Brazil e-mail:

jacson@unifei.edu.br Abstract: In this talk we will see an application of dynamical systems in medicine. A theoretical approach is done to propose math models to describe the drug concentration inside a human body in a medical treatment. Considering that the elimination could be nonlinear and the inaccuracy to determine the constant of elimination rate in the autonomous model, it is proposed that the elimination rate should be described by a bounded function and so the model becomes a nonlinear nonautonomous equation. Reference: J. Simsen, Nonlinear nonautonomous math models for drug concentration in the body, Mathematics in Engineering, Science and Aerospace, 2024, 15 (2), 579-589. Acknowledgements: Thanks to FAPEMIG for supporting my research.

Time Delay in a Mathematical Model of Epithelial--Mesenchymal Transitions and Implications for Cancer Treatment

Schedule: July 6 15:00-15:30 Room 433

Magdalena Szafranska-Leczycka

Doctoral School of Exact and Natural Sciences, University of Warsaw, Warsaw, Poland, Poland

Co-Author(s): K. Nec, Z. Szymańska, U. Foryś

Abstract:

In this presentation, we investigate the role of time delay in regulating epithelial--mesenchymal transition within the model based on Celi\`{a}-Terrassa et al. (2018). From the perspective of cancer treatment, such temporal effects may influence the effectiveness of therapeutic strategies targeting TGF- β pathways. Sensitivity analysis indicates that parameters associated with TGF- β degradation and autocrine production play a key role in controlling E-cadherin levels and, consequently, cellular phenotype. Moreover, following Herberitz et al. (2015), we simulate treatment strategies aimed at inhibiting EMT--MET transitions. The results of these simulations will be presented during the presentation.

Special Session 41 : Dynamics and Games

Organizer(s): Alberto Pinto , Michel Benaïm , Diogo Gomes

Introduction: The session aims to bring together world top researchers and practitioners from the fields of Dynamical Systems, Game Theory and applications to such areas as Biology, Economics, Engineering, Energy, Natural Resources and Social Sciences. This session is organized by the founders and editors-in-chief of the Journal of Dynamics and Games (JDG), published by the American Institute of Mathematical Sciences (AIMS).

Design of efficient mechanisms for industrial pollution control

Schedule: July 9 16:30-17:00 Room 822

Alberto A Alvarez-Lopez

UNED - Dep. Economic Theory and Mathematical Economics, Spain

Co-Author(s): Pinto, Alberto A.; Martins, Filipe

Abstract:

Industrial pollution and its limitation have become a very important concern. In this paper we consider a polluting industry and a government with the possibility of supervising this pollution. The interaction between the firms within the industry and the government is modelled as an evolutionary game. We show that, by defining an appropriate fine, the government can design a pollution control mechanism with which all firms optimally achieve the same level of pollution reduction---which we call green level, and in turn can be predetermined by the government. This mechanism requires a specific level of government's supervision for each firm that is proportional to the firm's cost of pollution reduction. We also provide two specific examples of fine to design the mechanism: piecewise affine and piecewise quadratic. The practical implementation of the former is much easier, but the latter exhibits the property that the rate of convergence to the green level is greater the more polluting the companies are. These properties are very relevant for applications in environmental policy.

The Centipede Game and Financial Bubbles

Schedule: July 9 17:00-17:30 Room 822

Bruno Dupire

Bloomberg/NYU, USA

Abstract:

The Centipede Game leads to a counterintuitive Nash equilibrium that destroys wealth. We study this game and investigate versions of the game that lead to a model of formation and burst of financial bubbles, where participants are first incentivized to feed the trend, then run for the exit. We analyze these mechanisms and examine how the model fits behavioral economics interpretations and the observed dynamics of financial bubbles.

Platform-induced coordination by Julian Chitiva and Penelope Hernandez

Schedule: July 9 17:30-18:00 Room 822

Penelope Hernandez

ERI-CES University of Valencia, Spain

Abstract:

We study how platforms influence collective action by strategically designing information networks. Users face a fundamental coordination trade-off, aligning actions with their private types while conforming to others' behaviour. In a Bayesian game where users receive private signals correlated with both their types and a payoff-relevant state, the platform controls which signals each user observes, shaping beliefs and equilibrium outcomes.

Stable coalition formation through bargaining for the preservation of public goods

Schedule: July 9 18:00-18:30 Room 822

Alberto Pinto

LIAAD INESC TEC, DM, FCUP, Portugal, Portugal

Co-Author(s): Elvio Accinelli, Atefeh Afsar, Filipe Martins, Jose Martins, Bruno M.P.M. Oliveira, Luis Quintas

Abstract:

The notion of Union is Strength is essential for preserving public goods and mitigating public bads such as air quality. International environmental agreements serve this role by forming stable coalitions, in which agents join or leave based on free-riding incentives. Building on the Baliga-Maskin model, we show that such coalitions can emerge from a simple Markov chain mechanism where agents enter or exit through utility-based bargaining. However, stable coalition formation is challenging, as members may receive substantially lower utility than free-riders. This asymmetry gives rise to Barrett's paradox of cooperation: even with large coalitions and strong preferences among free-riders, overall utility may remain far below that of the grand coalition. Encouragingly, the paradox of cooperation can be resolved when free-riders have sufficiently low preferences.

Convergence to Nash equilibria in monotone games and their characterization

Schedule: July 9 18:30-19:00 Room 822

Jarowit Sledzinsk

University of Warsaw, Faculty of Mathematics, Informatics and Mechanics, Poland

Abstract:

The first AI agent playing the board game Stratego on a human expert level was trained by Regularized Nash Dynamics (R-NaD), an algorithm which converges to Nash equilibria in zero-sum games. Such property of convergence is exceptional - a classical evolutionary game theory replicator dynamics is recurrent in zero-sum games. R-NaD converges to the equilibrium not only in zero-sum games but in a recently introduced wider class of the so-called monotone games. The original definition of the monotone games is difficult to interpret and was not investigated any further than showing it includes zero-sum games and some other known but tight classes. In this talk, we are going to briefly present the ideas behind R-NaD and show our own results concerning monotone games. We formulated a monotonicity-equivalent condition for 2-player games, which is much easier to interpret than the original one. This led us to look closer at the monotone games. We obtained a full classification of games with two strategies and symmetric games with three strategies with respect to pure Nash equilibria.

Special Session 42 : Hamiltonian Dynamics and Celestial Mechanics

Organizer(s): Zhifu Xie , Ernesto Perez-Chavala

Introduction: This special session will concentrate on the latest developments in the fields of Hamiltonian Dynamics and Celestial Mechanics. The study of the N-body problem, which laid the foundations for the birth of dynamical systems, continues to attract researchers from a wide range of fields such as variational calculus, algebraic and symplectic geometry, ergodic theory, topology, numerical analysis, and KAM theory. This session will include topics related to central configurations, the N-body problem in spaces of constant curvature, new periodic solutions, regularization of collisions, index theory and symplectic invariants, stability and instability of solutions, and applications to spacecraft orbital design. Leaders in the field, experts in different areas of dynamical systems, as well as young researchers, will have the opportunity to build an active and stimulating framework to exchange ideas, identify new research directions, and initiate new collaborations. If the schedule permits, we anticipate ending the session with a discussion on open problems.

On the Birkhoff conjecture for Kepler billiards

Schedule: July 6 14:00-14:30 Room 628

Vivina Barutello

University of Turin, Italy

Abstract:

We investigate the integrability of Kepler billiards-mechanical billiard systems in which a particle moves under the influence of a Keplerian potential and reflects elastically at the boundary of a strictly convex planar domain. Our main result establishes that, except possibly for one location of the gravitational center, analytic integrability at high energies occurs only when the domain is an ellipse and the center is placed at one of its foci. This provides a partial affirmative answer to a Keplerian analogue of the classical Birkhoff-Poritsky Conjecture. Our approach is based on the construction of symbolic dynamics arising from chaotic subsystems that emerge in the high-energy regime.

Reversing Symmetries and Periodic Motions in the Three-Body Problem on the Sphere

Schedule: July 6 15:00-15:30 Room 628

Abimael Bengochea

Instituto Tecnológico Autónomo de México, México

Co-Author(s): Ernesto Perez Chavela, Carlos Barrera Anzaldo

Abstract:

We identify reversing symmetries for the three body problem on the sphere. This framework is applied to compute choreographies on the sphere, particularly those related to the eight figure choreography of the classical planar case. This approach is a useful tool for the search of periodic solutions and for studying the motion of bodies in spaces of constant curvature, highlighting the role of symmetry in such settings.

Mass constraints of some planar central configurations

Schedule: July 6 13:30-14:00 Room 628

Kuochang Chen

National Tsing Hua University, Taiwan

Co-Author(s): Ke-Ming Chang

Abstract:

Determining relations between central configurations and masses is a challenging task in celestial mechanics. In this talk we will demonstrate some nontrivial techniques and criteria for the existence and uniqueness of some central configurations with 5 or 6 bodies. In particular, we will show criteria for rhomboidal and kite configurations with non-parallel masses.

A new class of pyramidal central configurations for spatial Newtonian 6-body problems

Schedule: July 6 14:30-15:00 Room 628

Liang Ding

Guizhou Minzu University, Peoples Rep of China

Co-Author(s): Liang Ding, Jin Wang, Jinrong Wang and Zhifu Xie

Abstract:

While it is known that a non-concyclic rhombus can form a central configuration in the planar 4-body problem, such a base is forbidden for pyramidal central configurations in the spatial 5-body problem. This paper demonstrates that this restriction does not hold for the spatial 6-body problem. We give an analytical proof of the existence of a novel class of pyramidal central configurations with a non-concyclic quadrilateral base, a structure that distinguishes them from all known spatial 5-body pyramidal central configurations. We derive several key properties associated with these new central configurations. Furthermore, we demonstrate that this new class can be utilized to construct perverse solutions in $\mathbb{R}^3$. We support our theoretical findings with numerical examples for each case.

A FAMILY OF LINEAR STABLE EQUILIBRIA IN THE SUN-EARTH-SAIL PROBLEM

Schedule: July 6 18:00-18:30 Room 628

Marcelo D Marchesin

FEDERAL UNIVERSITY OF MINAS GERAIS, Brazil

Abstract:

The collinear libration point of the Sun-Earth Circular Restricted Three-Body Problem (CR3BP), L3 is located opposite to the Earth with respect to the Sun. Whereas several space missions have been launched to the other two collinear equilibrium points, i.e., L1 and L2, the region around L3 is so far unexploited essentially because of the severe communication limitations caused by Sun's blocking location. By using an adequate size, location and attitude of a solar sail, the equilibrium point can be displaced from its original location to allow direct communication between the satellite and Earth. This paper presents several families of artificial equilibria located on the semi-space which is permanently opposite to Earth in relation to the Sun, but which allows direct communication with Earth. We present a family of such equilibria which are linearly stable and therefore very useful for space missions.

Dynamics and Symmetry: Minimizing brake orbits

Schedule: July 6 16:30-17:00 Room 628

Daniel Offin

Queen's University, Canada

Co-Author(s): Henry Kavle

Abstract:

The computation of the Conley-Zehnder index for periodic brake orbits of fixed energy E in classical mechanical systems can be resolved by decomposing the symplectic space of Jacobi fields along geodesic chords parameterized by Jacobi arclength, joining separated points on the Hill's boundary. Our result gives this decomposition in terms of orthogonal Jacobi fields along the extended geodesic. In this talk, we will discuss properties of minimizing brake orbits.

Relative equilibria on spaces of constant curvature

Schedule: July 6 17:30-18:00 Room 628

Ernesto Perez Chavela

ITAM Mexico, Mexico

Co-Author(s): Toshiaki Fujiwara

Abstract:

For $N = 3$, it is well known that on the Euclidean space there are exactly five relative equilibria: three collinear (Euler relative equilibria) and two planar relative equilibria forming an equilateral triangle (Lagrange relative equilibria). What happens when we curved the Euclidean space in positive or negative way? The big difficulty to study relative equilibria on these spaces, that we call RE by short, is the absence of the center of mass as a first integral, since many of the standard methods used in the classical case don't apply any more. In this talk we will show a geometrical method to study RE on these spaces, when the particles are moving under the influence of a general potential which only depends on the mutual distances among the masses. In particular we will show how to determine the rotation axis, which is a big obstacle to obtain RE . We restrict our analysis to the case $N = 3$, where we give some new families of Euler and Lagrange RE on the sphere for the cotangent potential (the natural extension of the Newtonian potential to the sphere).

C1 perturbations of a continuum of critical points

Schedule: July 6 15:30-16:00 Room 628

Antonio J Urena

Universidad de Granada, Spain

Co-Author(s): R. Ortega

Abstract:

Given a real-valued function having a nondegenerate compact manifold of critical points, some of these points survive under small C2-perturbations. This is a well-known result in critical point theory. In 1986, Weinstein obtained the analogous conclusions when the perturbation is only C1 and the ambient space is a finite-dimensional manifold. In this work we present a complete proof for C1 perturbations in infinite-dimensional Hilbert spaces. This is a joint work with R. Ortega

Comparison principle of general Hamilton-Jacobi equations and applications

Schedule: July 6 14:30-15:00 Room 628

Jianlu ZHANG

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

In this talk, we prove a new type comparison principle for Hamilton-Jacobi equations. We also propose some applications in understanding the global structure of solutions.

Integrable Kepler billiards and the Poncelet Porism

Schedule: July 6 17:00-17:30 Room 628

Lei Zhao

Dalian University of Technology, Peoples Rep of China

Co-Author(s): Daniel Jaud

Abstract:

In this talk I will review some recent works in the latest years concerning integrable Kepler billiards in the plane and some of their very nice geometrical properties. Some of these geometrical properties allow us to draw a direct link between their dynamics and the Poncelet porism, which in turn allows us to have a relatively easy analysis of their dynamics in terms of elliptic curves. We shall work out an example of an integrable Kepler billiard system inside an ellipse in the plane with negative energy.

Special Session 43 : Recent Advances in Inverse Problems, Imaging, and Their Applications

Organizer(s): Peijun Li , Gang Bao

Introduction: This session aims to bring together researchers from diverse fields to discuss recent developments in inverse problems and imaging. It will provide a platform for experts in modeling, analysis, and computational methods to exchange ideas and share insights on theoretical advancements and practical applications. Additionally, the session will explore emerging challenges and future research directions in these areas.

Data driven reduced order modeling approach to inverse scattering

Schedule: July 6 14:00-14:30 Room 437

Liliana Borcea

Columbia University, USA

Co-Author(s): Josselin Garnier, Alexander Mamonov, Jorn Zimmerling

Abstract:

Waveform inversion seeks to estimate an inaccessible heterogeneous medium by using sensors to probe the medium with signals and measure the generated waves. The traditional formulation, called full waveform inversion (FWI), estimates unknown coefficients in wave equations, that model the medium, via nonlinear least squares data fitting. For typical band limited and high frequency data, the data fitting objective function has spurious local minima near and far from the true coefficients. This is why FWI implemented with gradient based optimization can fail, even for good initial guesses. We propose a different approach to waveform inversion: First, use the data to learn a good algebraic model, called a reduced order model (ROM), of how the waves propagate in the unknown medium. Second, use the ROM to obtain a good approximation of the wave field inside the medium. Third, use this approximation to solve the inverse problem. I will give a derivation of such a ROM for a general first order hyperbolic system satisfied by all linear waves in lossless media (sound, electromagnetic or elastic). I will describe the properties of the ROM and will use it to solve the inverse problem for sound waves.

Reconstruction Algorithms for Multi-Slice Ptychography Based on Chain-Structured Modeling

Schedule: July 6 16:30-17:00 Room 437

Huibin Chang

Tianjin Normal University, Peoples Rep of China

Abstract:

Ptychography has emerged as a premier lensless imaging technique, offering sub-Angstrom resolution and exceptional phase contrast for characterizing nanomaterials. However, traditional 2D models rely on the thin-slice approximation, which fails to account for multiple scattering in thick or strongly scattering specimens. Existing multi-slice ptychography (msPtycho) algorithms, such as 3PIE, are often derived heuristically, lack rigorous convergence guarantees, and suffer from slow convergence or heavy computational burdens. To address these challenges, this talk introduces a novel chain-structured modeling approach that reduces complex multi-linear couplings into a sequence of bilinear relations. Based on this framework, we present the AM2SP algorithm, providing closed-form solutions and proven global convergence to stationary points. By incorporating forward-propagating correction and Nesterov-like extrapolation, the enhanced AM2SP-FX algorithm significantly suppresses error accumulation and accelerates reconstruction speed by over an order of magnitude compared to traditional baselines. Furthermore, we explore the integration of Implicit Neural Representation (INR) to maintain high-fidelity reconstruction quality even under large-step scanning geometries with low overlap ratios. This synergy between rigorous physical modeling and continuous neural representation offers a robust, scalable solution for high-resolution 3D imaging.

Uniqueness of an inverse cavity problem for the biharmonic equation

Schedule: July 7 16:30-17:00 Room 437

Heping Dong

Jilin University, Peoples Rep of China

Abstract:

This talk concerns cavity problems for the biharmonic equation in an unbounded Kirchhoff--Love plate. By applying a concentrated point force inside the plate and using two sets of boundary measurements, we address the inverse problem of determining an unknown cavity. A key component of the analysis is the construction of a Dirichlet-to-Neumann (DtN) map, which reduces the unbounded domain problem to an equivalent formulation on a bounded domain. This reduction enables a variational analysis and establishes the well-posedness of the direct problem and the uniqueness in recovering both the location and shape of the cavity by using of a unique continuation principle.

Subwavelength resonances and bandgaps in high contrast elastic system

Schedule: July 7 17:00-17:30 Room 437

Yixian Gao

Northeast Normal University, Peoples Rep of China

Abstract:

This talk develops a rigorous mathematical framework for subwavelength resonances and bandgaps in high-contrast elastic systems. Using variational methods, layer potential techniques, and Floquet-Bloch theory, we study 2D and 3D elastic wave scattering, establish a solid mathematical foundation for phononic crystal band structures, and provide reliable theoretical support for wave control and elastic metamaterial design.

Effective sound speed estimation in ultrasound imaging

Schedule: July 6 14:00-14:30 Room 437

Josselin Garnier

Ecole polytechnique, France

Co-Author(s): Laure Giovangigli, Quentin Goepfert, Pierre Millien

Abstract:

In this talk, we present a mathematical model and analysis for a new method to estimate the sound speed in ultrasound imaging. We first perform a detailed analysis of the point-spread function of an imaging system in the presence of a mismatch between the true sound speed in the medium and the speed used in the reverse-time imaging function. This analysis leads to an estimator of the sound speed in the presence of a point-like reflector (a guide star). In a second part, we consider a random multiscale medium (modeling biological tissue for instance) and use stochastic homogenization techniques to derive a representation formula for the scattered field. We then show that statistical moments of the imaging functional can be recovered from data corresponding to a single realization of the medium. We demonstrate that the point-spread function can be extracted directly from speckle patterns, making it possible to estimate the effective sound speed even in the absence of a point-like reflector.

Shape optimization driven regularization methods for bioluminescence tomography

Schedule: July 6 17:00-17:30 Room 437

Rongfang Gong

Nanjing University of Aeronautics and Astronautics, Peoples Rep of China

Co-Author(s): Wei Gong, Shengfeng Zhu, Qianqian Wu, Ziyi Zhang

Abstract:

In this talk, we investigate the inverse source problem arising in bioluminescence tomography, the objective of which is to reconstruct both the support and the intensity of an internal light source from boundary measurements governed by an elliptic model. A shape optimization framework is developed in which the source intensity and its support are decoupled through first-order optimality conditions. To enhance the stability of the reconstruction, we incorporate a parameter-dependent coupled complex boundary method together with perimeter and volume regularizations. Source support is represented by a level set function, allowing the algorithm to naturally accommodate topological changes and recover multiple, closely spaced, or nested source regions. Theoretical justifications for the proposed formulation and regularization strategy are established, and extensive numerical experiments are performed to assess the reconstruction accuracy for both noise-free and noisy data. The results demonstrate that our method achieves robust and accurate recovery of source geometry and intensity, exhibits clear advantages over existing approaches.

Nonlinear Transformation Based Infinite-Dimensional Variational Inference for Statistical Inverse Problems

Schedule: July 7 17:30-18:00 Room 437

Junxiong Jia

Xi'an Jiaotong University, Peoples Rep of China

Abstract:

Inverse problems for PDEs are common in scientific disciplines and can be formulated as statistical inference problems via Bayes theorem. For large-scale problems, developing discretization-invariant algorithms is crucial, achievable by formulating methods in infinite-dimensional spaces. Restricting the variational family to the pushforward of a prior measure's nonlinear transformation yields various variational inference methods. Overcoming singularity issues in infinite-dimensional function spaces, we develop two methods: infinite-dimensional Stein variational gradient descent (iSVGD) and functional normalizing flows (FNF). The transformations in both iSVGD and FNF involve a sequence of identity operator perturbations. In iSVGD, perturbation mappings are in a reproducing kernel Hilbert space, while in FNF, they are constructed with designed neural network architectures. We apply these algorithms to an inverse problem of the steady-state Darcy flow equation. Numerical results validate the theoretical analysis, show the algorithms' efficiency, and confirm their discretization-invariant properties.

Selective focusing of multiple particles in a layered medium

Schedule: July 7 13:30-14:00 Room 437

Jun Lai

Zhejiang University, Peoples Rep of China

Co-Author(s): Jinrui Zhang

Abstract:

Inverse scattering in layered media has a wide range of applications, including geophysical exploration, submarine detection, and medical imaging. In this talk, we develop a selective focusing method for identifying multiple unknown buried scatterers in a layered medium. The method is derived through asymptotic analysis of the time reversal operator, which is challenging due to the absence of an explicit form for the layered Green's function and the limited aperture measurements. We demonstrate that each small sound-soft and sound-hard particle gives rise to one and three significant eigenvalues, respectively, and the corresponding eigenfunction generates an incident wave focusing selectively on each unknown particle. Finally, we employ the time reversal method as an initial indicator and propose an effective Bayesian inversion scheme to reconstruct multiple buried extended scatterers for enhanced resolution. Numerical experiments are provided to demonstrate the efficiency.

On the identification of external forces for two-layer quasi-geostrophic model from partial observation data

Schedule: July 7 14:00-14:30 Room 437

Jijun Liu

Southeast University, Peoples Rep of China

Abstract:

The two-layer quasi-geostrophic model can be considered as a simplified version of 3-dimensional Navier-Stokes equation governing the evolution process of ocean flow in stratified homogeneous medium. The potential vorticity and the stream functions in two adjoint layers are coupled together in a nonlinear PDE system, representing the dynamical evolution by external forces and the interactions between two layers. Due to the large scale of the spatial domain for ocean flow, the external forces cannot be observed directly. We consider an inverse problem for the recovery of external forces which are the main factors motivating the ocean flow evolution, with the stream functions measured only in part of the spatial domain as inversion input. Based on the equivalent representation of the solution to PDE systems, this nonlinear ill-posed problem is decomposed into two problems: one is a linear ill-posed problem essentially based on the extension of the solutions of linear elliptic system, the other is a nonlinear ill-posed problem from the numerical differentiations. We establish a reconstruction scheme by solving these two ill-posed problems with rigorous mathematical analysis, including the solvability of the regularizing system, the optimal choice strategy for regularizing parameters, and the error estimates on the recovered solution. The relation between the noise level of inversion input data, the resolution accuracy of the unknown sources and the reconstruction errors is quantitatively characterized by matrix decomposition and Fourier analysis techniques. Numerical implementations are presented to show the validity of our proposed scheme.

Inverse scattering problems from the multi-frequency backscattering data

Schedule: July 6 14:30-15:00 Room 437

Xiaodong Liu

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

Inverse scattering from backscattering data is a foundational and impactful research area at the intersection of applied mathematics, computational physics, and engineering, with profound implications for critical real-world applications such as non-destructive testing, medical imaging, radar systems, and remote sensing. This research direction focuses on retrieving the geometric and physical properties of unknown scatterers (e.g., obstacles, inhomogeneous media) using only backscattered wave measurements-where the source and receiver are co-located or aligned in a backscattering configuration-a setup that is widely adopted in practical scenarios due to its simplicity and operational efficiency. In this talk, we introduce some uniqueness and numerical algorithms on this topic. In particular, our numerical algorithms avoid computing the direct problems.

Numerical algorithms for high-frequency wave propagation problems and related Hamilton-Jacobian equations

Schedule: July 7 8:00-8:30 Room 437

Wangtao Lu

Zhejiang University, Peoples Rep of China

Abstract:

In this talk, I will present fast algorithms for computing the highly oscillatory solutions in high-frequency wave propagation problems. The method is based on asymptotic ansatz which gives rise to unknowns independent of the frequency, governed by coupled Hamilton-Jacobian equations usually. I will show some theoretical and numerical results regarding solving such hyperbolic equations.

Local reconstruction of coefficients in quantitative photoacoustic tomography

Schedule: July 6 15:00-15:30 Room 437

Faouzi Triki

Universite de Grenoble, France

Co-Author(s): Mirza Karamehmedovic

Abstract:

Quantitative photoacoustic tomography (QPAT) seeks to recover optical parameters of a medium from internal absorbed-energy data generated by optical illumination and measured through acoustic waves. In practice, these data are most reliable only near the illuminated boundary, since attenuation and limited detector sensitivity reduce their usefulness at greater depth. This motivates a local inverse problem: reconstructing the absorption and scattering coefficients only in a boundary layer where the signal remains informative. We consider the stationary radiative transport equation in a smooth bounded domain, with absorption coefficient μ_a , scattering coefficient μ_s , and a prescribed scattering kernel. For a given inflow illumination g , the internal data take the form

$$H(x, g) = \mu_a(x) \int_{\mathbb{S}^{n-1}} u(x, d) ds(d),$$

where u denotes the photon density, solution to the radiative transport equation. We show that with a finite number of suitably chosen illuminations, one obtains a local linear system whose invertibility guarantees unique recovery of the coefficients up to higher-order depth errors. The analysis provides a rigorous explanation of depth-limited resolution in (QPAT) and suggests a practical reconstruction strategy in strongly attenuating media. Numerical experiments support the asymptotic model and illustrate stable coefficient recovery in shallow subregions near the boundary.

Efficient Numerical Methods for an Inverse Source Problem of the Wave Equation via Droplet-Induced Asymptotics

Schedule: July 7 14:30-15:00 Room 437

Haibing Wang

Southeast University, Peoples Rep of China

Co-Author(s): Shutong Hou and Mourad Sini

Abstract:

In this talk, we show two novel approaches for solving the inverse source problem of the acoustic wave equation in three dimensions. By injecting a small high-contrast droplet into the medium, we exploit the resulting wave field perturbation measured at a single external point over time. First, we derive an asymptotic expansion of the wave field after the droplet injection, using the eigensystem of the Newtonian operator, with error analysis for the spectral truncation. Then two novel numerical methods for reconstructing the source via the expansion and mollification-based numerical differentiation. Our methods require only single-point measurements, overcoming traditional spatial data limitations. Several numerical experiments are presented to demonstrate the performance of the proposed methods.

Research on nonradiating sources of Maxwell's equations

Schedule: July 7 18:00-18:30 Room 437

Jue Wang

Hangzhou Normal University, Peoples Rep of China

Abstract:

This talk presents a thorough investigation into nonradiating sources of Maxwell equations. Various characterizations are developed to clarify the properties of nonradiating sources, considering their varying degrees of regularity. Furthermore, the characterizations are examined on far-field patterns and near-field data of the electric field, along with the null spaces of integral operators. The study includes the explicit construction of several illustrative examples to demonstrate the presence of nonradiating sources in different null spaces.

Multi-Frequency Unsupervised Deep Learning for Precise Inverse Acoustic Scattering

Schedule: July 7 15:00-15:30 Room 437

Yuliang Wang

Wenzhou-Kean University, Peoples Rep of China

Abstract:

This talk presents a robust unsupervised deep learning approach for reconstructing the location and shape of impenetrable sound-soft obstacles in two dimensions from scattered field data. The method formulates the inverse acoustic scattering problem as a PDE-constrained shape optimization, where the obstacle boundary is parameterized by a neural network, and the forward problem is solved efficiently using the Discrete Source Method. Reconstruction accuracy is enhanced through a multi-frequency continuation strategy, in which low-frequency reconstructions are progressively refined using higher-frequency data. Moreover, targeting phaseless far-field data, we propose an imaging algorithm for obstacle localization, which is coupled with deep learning approach to thereby reconstruct the obstacle's shape with high precision. The approach leverages automatic differentiation to compute gradients, avoiding the need for adjoint solvers, and integrates multi-angle measurements for improved stability. Numerical experiments demonstrate accurate recovery of complex geometries, including sharp corners and multiple obstacles, even under sparse sampling and severe noise.

Direct and inverse problems in thermoelasticity

Schedule: July 7 8:30-9:00 Room 437

Tao Yin

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

This talk will present a brief summary of our recent works on the direct and inverse thermoelastic wave scattering problems, including the spectral analysis of regularized boundary integral equation methods and numerical experiments for the problem of thermoelastic scattering by an open-arc, and some stability estimates for the inverse source problems in thermoelasticity.

Convergence of the DtR methods for the wave scattering by periodic structures

Schedule: July 7 9:00-9:30 Room 437

Xiaokai Yuan

Jilin University, Peoples Rep of China

Abstract:

This talk presents a rigorous analysis of the Dirichlet-to-Robins (DtR) method for acoustic and elastic wave scattering by periodic structure. The variational problem is formulated by employing a DtR-based transparent boundary condition. The analysis establishes that the truncated problem is well-posed provided the DtR operator incorporates all propagating modes. Furthermore, through both a posteriori and a priori error estimates, it is proved that the solution obtained with the truncated DtR operator converges exponentially to the exact solution as the truncation number N increases.

Recovery of weakly anisotropic elastic parameters

Schedule: July 7 15:00-15:30 Room 437

Jian Zhai

Fudan University, Peoples Rep of China

Abstract:

We consider the recovery of an anisotropic perturbation of an isotropic elastic body. When the reference isotropic body is homogeneous we show that the anisotropic perturbation can be fully determined by single-scattered waves. When the reference model is heterogeneous, the problem can be reduced to certain tensor tomography problems for which related results will also be discussed.

A reduce order method for optimal design in scattering problems

Schedule: July 6 15:00-15:30 Room 437

Hai Zhang

HKUST, Hong Kong

Co-Author(s): Yu Gao and Kai Zhang

Abstract:

We propose a computational framework for the optimal design of broadband absorbing materials made of plasmonic nanoparticle arrays. Designing these materials is challenging due to complex multi-particle interactions, broadband frequency requirements, difficult shape derivative calculations, and a non-convex optimization landscape. To overcome these issues, we employ three strategies: a parameterized integral equation formulation to bypass traditional shape derivative computations; a shape-adaptive reduced basis method (RBM) utilizing Neumann-Poincaré operator eigenfunctions to accelerate forward and adjoint problem computations; and a physics-informed initialization strategy based on weak coupling assumptions to enhance gradient-based optimization. Numerical experiments demonstrate that this flexible and extensible framework yields accurate and computationally efficient designs across various geometric configurations.

Uniform far-field asymptotics for scattering by unbounded rough surfaces and application to the inverse problem

Schedule: July 6 15:30-16:00 Room 437

Haiwen Zhang

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Yue Dong

Abstract:

This talk is concerned with direct and inverse scattering by an unbounded rough surface with the Dirichlet boundary condition in two dimensions. We study the asymptotics of the solution to the considered scattering problem with the boundary data in a weighted space of continuous functions. Based on this, we develop a direct imaging method for recovering the unbounded rough surface from the scattered-field data generated by incident point sources. Numerical experiments are carried out to demonstrate the feasibility and robustness of our algorithms.

Inverse Problems of Output Feedback Controller via Contraction Metrics

Schedule: July 7 15:30-16:00 Room 437

Lei Zhang

Zhejiang University of Technology, Peoples Rep of China

Abstract:

This talk presents an output feedback robust model predictive control (MPC) method for stabilizing nonlinear systems with additive disturbances and noisy output measurements. A robustly stable observer updates the estimation error set magnitude online, which is then used in the controller design for a predictive control inverse problem. By leveraging the sublevel set defined by the Riemannian distance, a set-valued system is constructed around the predicted trajectory. Reachability analysis parameterizes this set-valued system to obtain tube dynamics, forming the basis for robust constraint conditions. The proposed framework removes the need for explicit geodesics, avoiding online synthesis of auxiliary controllers. Additionally, two exponentially convergent observers are developed through contraction analysis, and a method for improving output feedback via online set-valued estimation is introduced. Numerical simulations show the effectiveness of the proposed approach in stabilizing the system while satisfying state and control input constraints.

Generative models for solving linear and nonlinear inverse problems

Schedule: July 6 17:30-18:00 Room 437

Xiaoqun Zhang

Shanghai Jiao Tong University, Peoples Rep of China

Co-Author(s): Xiang Cao, Qiaoqiao Ding

Abstract:

Diffusion models have emerged as powerful tools for solving nonlinear inverse problems, offering high-quality reconstructions through conditional reverse sampling. However, challenges persist in handling partial differential equation (PDE)-constrained inverse problems, including computational inefficiency, discretization errors, and the inherent ill-posedness of nonlinear systems such as travel-time tomography and ultrasound computed tomography (USCT). In this talk, we present two synergistic frameworks that address these challenges by integrating diffusion priors with PDE-aware numerical and learned solvers. First, we propose a subspace diffusion approach for PDE-based travel-time tomography, introducing (1) a plug-and-play posterior sampling process that leverages adjoint-state equations for gradient updates and (2) a coarse-to-fine subspace acceleration technique to reduce sampling time while preserving reconstruction quality. Second, we develop Diff-ANO (Diffusion-based Models with Adjoint Neural Operators), a unified framework for Helmholtz equation-constrained USCT that combines (1) a conditional consistency model for few-step, measurement-conditional sampling and (2) neural operator surrogates to replace traditional PDE solvers, enabling memory-efficient adjoint gradient computation via our Batch-based Convergent Born Series (BCBS) strategy. Our experiments demonstrate significant improvements in both reconstruction accuracy and computational efficiency across sparse-view and partial-view measurement scenarios. The proposed methods bridge the gap between generative priors and PDE constraints, offering scalable solutions for nonlinear inverse problems in imaging.

Neural network yields regularization for ill-posed inverse problems

Schedule: July 6 15:30-16:00 Room 437

Ye Zhang

Shenzhen MSU-BIT University, Peoples Rep of China

Abstract:

In this talk, we establish universal approximation theorems for neural networks applied to general nonlinear ill-posed operator equations. In addition to the approximation error, the measurement error is also taken into account in our error estimation. We introduce the expanding neural network method as a novel iterative regularization scheme and prove its regularization properties under different a priori assumptions about the exact solutions. Within this framework, the number of neurons serves as both the regularization parameter and iteration number. We demonstrate that for data with high noise levels, a small network architecture is sufficient to obtain a stable solution, whereas a larger architecture may compromise stability due to overfitting. Furthermore, under standard assumptions in regularization theory, we derive convergence rate results for neural networks in the context of variational regularization. Several numerical examples are presented to illustrate the robustness of the proposed neural network-based algorithms.

STDDM for the Helmholtz equation in inhomogeneous medium

Schedule: July 7 9:30-10:00 Room 437

Weiying Zheng

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Yuhao Wang

Abstract:

In this talk, I will study the source-transfer-domain-decomposition method (STDDM) for solving high-frequency scattering problem of Helmholtz equation in a background medium with compact inhomogeneity. We first truncate the unbounded domain with the uniaxial perfectly matched layer (UPML) method. An wavenumber-explicit infsup condition is proved for the bilinear form of the truncated PML problem, where the infsup constant is shown to be $O(k \ln k)$, with k being the wavenumber. Based on this infsup condition, we obtain preasymptotic finite element error estimates for the finite element approximation to the truncated problem. We propose an STDDM for solving the truncated PML problem and have proved the convergence of the method.

Special Session 45 : Frontiers in Topological Dynamics: Theory, Applications, and Interdisciplinary Connections

Organizer(s): Guohua Zhang , Wen Huang , Song Shao

Introduction: Topological dynamics is an important branch analyzing complex phenomena that arise from the interaction between topological structures and dynamical evolution. Its capacity to characterize qualitative behaviors of dynamical systems — such as stability, chaos, and long-term patterns — has led to many interesting applications in geometry, number theory, statistical physics, and beyond. The purpose of the special session aims to bring together people working on different aspects of this topic. The session will focus on both classical and modern aspects of the field, including symbolic dynamics, minimal systems, entropy theory, recurrence properties, ergodic theory, chaos theory, and connections to geometric or measurable dynamics. The session will particularly encourage contributions that explore links between topological dynamics and related fields, such as operator algebras, fractal geometry, or machine learning.

Physical measures for a class of partially hyperbolic attractors

Schedule: July 7 9:30-10:00 Room 440

Yongluo Cao

Soochow University, Peoples Rep of China

Co-Author(s): Zeya Mi

Abstract:

Title: Physical measures for a class of partially hyperbolic attractors **Abstract:** In this talk, we consider the existence of physical measure for partially hyperbolic attractors. If the systems's central direction can be decomposed into one dimension sub-bundles which are dominated splitting, and all u-gibbs measures are hyperbolic, then there exist finite physical measures.

Invariant measure for infinite Iterated Function Systems

Schedule: July 7 17:30-18:00 Room 440

Xiaopeng Chen

Shantou UNiversity, Peoples Rep of China

Abstract:

In this talk we define some infinite iterated function systems. We study the Ruelle operator theorem for the infinite iterated function systems. We prove the existence and uniqueness of the invariant measure for these types of systems.

On Entropy-like Invariants for Dynamical Semigroup Actions

Schedule: July 7 14:00-14:30 Room 440

Wen-Chiao Cheng

Chinese Culture University, Taiwan

Abstract:

During this talk, entropy-like invariants are first introduced and presented. Some questions will be shown and then talk about conditional entropy's propositions. Variational principle, subadditivity and commutativity properties for entropy and pressure are also shown. Furthermore, some new results are also exhibited to see what we can do next step for semigroup action on entropy propositions.

A Geometric Framework for Stochastic Dynamics on Manifolds of Probability Densities

Schedule: July 7 16:30-17:00 Room 440

Jinqiao Duan

Great Bay University, Peoples Rep of China

Abstract:

Traditional analysis of stochastic systems often relies on pathwise trajectories within Euclidean space. However, a more profound understanding of complex phenomena, such as critical transitions, emerges when these systems are viewed as evolutions on a manifold of probability densities. This talk explores this geometric perspective on the Onsager Machlup most probable paths, Schrodinger bridges, and information geodesics. This provides a cohesive framework that links calculus of variations and information geometry, offering new insights into the most probable behaviours of uncertain systems.

Threshold dynamics of two diffusive epidemic models with heterogeneity parameters

Schedule: July 7 17:00-17:30 Room 440

Lian Duan

Anhui University of Science and Technology, Peoples Rep of China

Abstract:

In this talk, I will report the threshold dynamics of two class of diffusive epidemic models with heterogeneity parameters. One is diffusive ZIKV epidemic model, and another is diffusive SIRS epidemic model. Our analyses show that the basic reproduction number which serves as a threshold parameter that predicts whether epidemics will persist or become globally extinct. For the latter, the asymptotic profiles of the positive steady state are also discussed.

Some interactions between Dynamical systems and Harmonic analysis

Schedule: July 8 8:00-8:30 Room 440

Aihua Fan

Central Normal University, Peoples Rep of China

Abstract:

Any locally compact Abelian (LCA) group acts on a torus $\mathbb{T}^n$ of arbitrary dimension. We show that this action admits a decomposition into uniquely ergodic subsystems. As application, the famous Kronecker theorem on Diophantine approximations (density) is then strengthened into a Weyl-type theorem (equidistribution). This allows us to show that the characters of an LCA group are orthogonal in the sense of Bohr and other consequences follow. Furthermore, we show that the algebra of quasi-periodic functions with spectra in a $\mathbb{Z}$ -module of finite rank n is isometrically isomorphic to the algebra $C(\mathbb{T}^n)$ of continuous periodic functions. This is the theoretical foundation upon which the projection method in scientific computation is based. As a theoretical application of this algebra isomorphism, we can prove, in a very simple way, the Hausdorff-Young inequalities for almost periodic functions in the sense of Besicovitch. This last part is a joint work with Kai JIANG and Pingwen ZHANG.

A Parabolic System for Bacterial Colony Dynamics

Schedule: July 7 8:00-8:30 Room 440

Zhaosheng Feng

University of Texas Rio Grande Valley, USA

Abstract:

In this talk, we present a nonlinear parabolic system incorporating dispersion to model bacterial aggregation dynamics. In contrast to models without dispersion, the inclusion of dispersive effects enables the propagation of bacterial clusters, suggesting that dispersion may serve as a regulatory mechanism in colony behavior. Through theoretical analysis and numerical simulations, we show that an initially random bacterial distribution evolves into a periodic wave pattern, in the absence of dispersion, this pattern ultimately transitions into a stationary solitary wave.

Symplectic blenders near whiskered tori and persistence of saddle-center homoclinics

Schedule: July 8 9:00-9:30 Room 440

Dongchen Li

Shanghai Center for Mathematical Sciences, Fudan University, Peoples Rep of China

Co-Author(s): Dmitry Turaev

Abstract:

A blender is a hyperbolic basic set such that the projection of its stable/unstable set onto some center subspace has a higher topological dimension than the set itself. We prove that, for any C^s symplectic diffeomorphism (where $s = 2, \dots, \infty, \omega$), if it has a one-dimensional whiskered torus with a homoclinic orbit, then a symplectic blender can be created by an arbitrarily C^s -small perturbation. Using this result, we show that the non-transverse homoclinic intersection between the invariant manifolds of a saddle-center periodic point is persistent, in the sense that the original system lies in the C^s -closure of a C^1 -open set of symplectic diffeomorphisms where those having saddle-center homoclinics are dense. Our results also hold in the corresponding continuous-time settings.

The equivalence of precompactness, zero maximal pattern entropy and bounded mean complexity for finite partitions

Schedule: July 8 16:30-17:00 Room 440

Jian Li

Shantou University, Peoples Rep of China

Co-Author(s): Tao Yu, Xianliang Zhong

Abstract:

In this talk, we discuss several types of low complexity of finite partitions in a standard probability space, including precompactness, zero maximal pattern entropy, bounded mean complexity and mean equicontinuity. We show that a collection of finite partitions is precompactness in the Rokhlin metric if and only if it has zero maximal pattern entropy if and only if the collection of the characteristic functions of atoms in the partitions is precompactness in L^2 if and only if it has bounded mean complexity with respect the Hamming distance. Then we apply this result to the complexity of a partition of countably infinite discrete amenable group actions. This talk is based on a joint work with Tao Yu and Xianliang Zhong.

Mean weak length

Schedule: July 7 8:30-9:00 Room 440

Bingbing Liang

Soochow University, Peoples Rep of China

Abstract:

We introduce a weak version of the classical length function, termed the weak length function, defined on subsets of R -modules over a unital ring R , and further consider the concept of mean weak length for $R\Gamma$ -modules associated with an amenable group Γ . Under an appropriate upgrading condition together with certain mild assumptions, we establish that the mean weak length function is additive with respect to short exact sequences. This result has two consequences. First, we provide a purely algebraic proof of the additivity of algebraic entropy, which is originally established via topological entropy methods. Second, within our unified framework, we give an alternative and conceptual proof of the additivity of mean length, previously obtained by Li-Liang and Virilli using different approaches.

Dynamical systems and their induced systems

Schedule: July 8 15:00-15:30 Room 440

Kairan Liu

Chongqing University, Peoples Rep of China

Co-Author(s): Hanfeng Li; Yixiao Qiao; Runju Wei

Abstract:

In this report, we will discuss the topological and dynamical connections between dynamical systems and their induced systems, including openness of relatively factor maps, relative mean dimension, and local entropy theory.

Continuity of the Lyapunov exponent and measure entropy for stochastic differential equations

Schedule: July 7 13:30-14:00 Room 440

Zhenxin Liu

Dalian University of Technology, Peoples Rep of China

Co-Author(s): Lixin Zhang

Abstract:

For non-autonomous linear stochastic differential equations (SDE), we establish that the top Lyapunov exponent is continuous if the coefficients almost uniformly converge. For autonomous SDEs, assuming the existence of invariant measures and the convergence of coefficients and their derivatives in pointwise sense, we get the continuity of all Lyapunov exponents.

Furthermore, we talk about the Lipschitz and Holder continuity of Lyapunov exponents. For autonomous SDEs, we establish a relationship between the measure entropy of the stochastic flow and the rate of volume growth of stable submanifolds under iteration. By combining the results of Kifer and Yomdin, we obtain that for such systems with C^∞ coefficients, under suitable integrability conditions, the measure entropy is upper semicontinuous with respect to the coefficients.

Periodic and Horseshoe-like Structures in Partially Hyperbolic Systems

Schedule: July 8 14:30-15:00 Room 440

Xiao Ma

University of Science and Technology of China, Peoples Rep of China

Co-Author(s): Xinyu Bai, Wen Huang, Zeng Lian, Leiye Xu, Hang Zhao

Abstract:

This talk explores periodic and horseshoe-like structures in partially hyperbolic systems, with an emphasis on how these structures relate to the complexity of the system, including entropy and expansion rates. The presentation is based on joint works with Xinyu Bai, Wen Huang, Zeng Lian, Leiye Xu, and Hang Zhao.

Uniform rokhlín property and double variational principle for mean dimension

Schedule: July 8 8:30-9:00 Room 440

Ruxi Shi

Fudan University, Peoples Rep of China

Co-Author(s): Alessandro Codenotti and Petr Naryshkin

Abstract:

As a new topological invariant, the notion of mean topological dimension was introduced by Gromov (1999). Then it was developed systematically by Lindenstrauss and Weiss (2000). Under marker property, Lindenstrauss and Tsukamoto (2019) developed a variational principle between mean dimension theory and rate distortion theory. In this talk, we extend Lindenstrauss-Tsukamoto double variational principle to dynamics of amenable group action with uniform rokhlin property. This talk is based on the ongoing work with Alessandro Codenotti and Petr Naryshkin.

Development of Bowen's specification legacy on thermodynamic formalism and applications to stochastic properties

Schedule: July 7 9:00-9:30 Room 440

Tianyu Wang

School of Mathematical Sciences Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

In 1970's, Rufus Bowen proposed a general criterion on establishing thermodynamic formalism of a dynamical system by extracting critical features of a uniformly hyperbolic system equipped with a Hölder continuous potential. Precisely, he showed that on an expansive homeomorphism satisfying a strong orbital concatenation property called specification, any boundedly distorted continuous potential must possess a unique equilibrium state. In this talk, we briefly survey the development of Bowen's argument in the past two decades by illustrating how Bowen's idea is extended to a variety of systems beyond compact uniform setting. This includes the introduction of a recent variant of Bowen's approach, as well as its applications on detecting a few types of strong stochastic behaviors

Preimage Mean Dimension

Schedule: July 7 15:00-15:30 Room 440

Xinsheng Wang

Shantou University, Peoples Rep of China

Co-Author(s): Weisheng Wu, Yujun Zhu

Abstract:

In this talk, the mean dimension theory via the preimage structure for noninvertible infinite dimensional dynamical systems with infinite topological entropy is considered. Several invariants, such as the topological preimage mean dimensions, the metric preimage mean dimensions and the rate distortion preimage mean dimensions involving two variables (metrics and measures) are introduced and the relations among these quantities are considered. Particularly, for a non-invertible system with the backward marker property, a double variational principle relating rate distortion preimage mean dimensions and topological preimage mean dimension is established. This is a joint work with Weisheng Wu and Yujun Zhu.

Product saturation theorem in polynomials

Schedule: July 7 15:30-16:00 Room 440

Qinqi Wu

Shanghai University of Finance and Economics, Peoples Rep of China

Co-Author(s): Jiaqi Yu

Abstract:

In this talk, we introduce the saturation theorem in product systems for polynomials. It is a joint work with Jiaqi Yu.

Symmetry vs Ergodicity

Schedule: July 8 13:30-14:00 Room 440

Disheng Xu

Great Bay University, Peoples Rep of China

Abstract:

In this talk, I will present my joint work with Damjanovic, Wilkinson and Wu. More precisely I will show for smooth dynamics, at least for affine maps on homogeneous spaces, ergodic theoretic property of a dynamical system is closely related to its symmetries.

Almost Countable Spectrum and Logarithmic Sarnak Conjecture

Schedule: July 7 14:30-15:00 Room 440

Leiye Xu

University of Science and Technology of China, Peoples Rep of China

Co-Author(s): Wen Huang and Maoru Tan

Abstract:

We introduce topological dynamical systems with almost countable spectrum. We prove that the Logarithmic Sarnak Conjecture holds for zero-entropy topological dynamical systems whose spectrum is almost countable. This class includes Anzai skew product on $\mathbb{T}^2$ over a rotation of $\mathbb{T}^1$, time-one maps of continuous suspension flows over rotations, systems with finite maximal pattern entropy, and bounded tame systems.

Metric mean dimension of amenable group actions via entropy of subsets

Schedule: July 8 9:30-10:00 Room 440

Ruifeng Zhang

Hefei University of Technology, Peoples Rep of China

Co-Author(s): Xinyao He and Guohua Zhang

Abstract:

We investigate the theory of metric mean dimension for actions of countable discrete amenable groups on compact metric spaces. We introduce the metric mean dimension, packing metric mean dimension, and Bowen metric mean dimension, respectively, using the topological entropy, packing topological entropy and Bowen's dimensional entropy, and establish the equivalence among these three metric mean dimensions. Our main results demonstrate that the global metric mean dimension of the system can be completely characterized by the asymptotic behavior of various entropies of local sets, particularly the ϵ -stable sets at individual points. These results generalize previous work on single transformations, and provide new tools for studying dynamical systems with infinite topological entropy. This is a joint work with Xinyao He and Guohua Zhang.

On fast Lyapunov spectra for Markov-R $\backslash\backslash\{e\}$ nyi maps

Schedule: July 8 17:00-17:30 Room 440

Yiwei Zhang

Anhui University of Science and Technology, Peoples Rep of China

Co-Author(s): Lulu Fang, Carlos Gustavo Moreira, Zhichao Wang

Abstract:

In this talk, we study the multifractal analysis for Markov-R $\backslash\backslash\{e\}$ nyi maps, which form a canonical class of piecewise differentiable interval maps, with countably many branches and may contain a parabolic fixed point simultaneously, and do not assume any distortion hypotheses. We develop a geometric approach, independent of thermodynamic formalism, to study the fast Lyapunov spectrum for Markov-R $\backslash\backslash\{e\}$ nyi maps. Our study can be regarded as a refinement of the Lyapunov spectrum at infinity. We demonstrate that the fast Lyapunov spectrum is a piecewise constant function, possibly exhibiting a discontinuity at infinity. Our results extend the works in \cite[Theorem 1.1]{FLWW13}, \cite[Theorem 1.2]{LR}, and \cite[Theorem 1.2]{FSW} from the Gauss map to arbitrary Markov-R $\backslash\backslash\{e\}$ nyi maps, and highlight several intrinsic differences between the fast Lyapunov spectrum and the classical Lyapunov spectrum. Moreover, we establish the upper and lower fast Lyapunov spectra for Markov-R $\backslash\backslash\{e\}$ nyi maps.

Discrete spectrum of probability measures for locally compact group actions

Schedule: July 8 17:30-18:00 Room 440

Xiaomin Zhou

Huazhong University of Science and Technology, Peoples Rep of China

Co-Author(s): Zongrui Hu, Xiao Ma, and Leiye Xu

Abstract:

In this talk we study discrete spectrum of probability measures for locally compact group actions. It turns out that a probability measure has discrete spectrum if and only if it has bounded measure-max-mean-complexity. As an application, an invariant measure of a locally compact amenable group action has discrete spectrum if and only if it has bounded mean-complexity along Følner sequences. This is a joint work with Zongrui Hu, Xiao Ma, and Leiye Xu.

Variational principles for (metric) mean dimension

Schedule: July 8 14:00-14:30 Room 440

Xiaoyao Zhou

Nanjing Normal University, Peoples Rep of China

Abstract:

Mean dimension is a topological invariant of topological dynamical systems, first introduced by Gromov. Subsequently, Lindenstrauss and Weiss conducted further investigations on this quantity, aiming to address an embedding problem proposed by Auslander in the 1970s. Furthermore, from the perspective of entropy theory, they introduced the concept of metric mean dimension. In 2018--2019, Lindenstrauss and Tsukamoto established the variational principles for (metric) mean dimension. In this talk, we present our recent progress regarding the variational principles for (metric) mean dimension.

Special Session 46 : Advances in Optimization and Equilibrium Problems: methods and applications

Organizer(s): Patrizia Daniele , Laura Palagi

Introduction: The study of optimization and equilibrium problems plays a central role in a wide range of scientific disciplines, including mathematics, engineering, economics, and data science. This session aims to bring together researchers working on both theoretical and applied aspects of optimization and equilibrium theory, with a special focus on recent advances in methods and innovative applications. Topics of interest include, but are not limited to, convex and non-convex optimization, variational inequalities, game theory, fixed-point problems, and saddle-point formulations. Contributions exploring numerical methods, algorithmic developments, and convergence analysis are particularly welcome, as well as those addressing computational challenges and large-scale problems. A key goal of the session is to foster cross-disciplinary dialogue, highlighting how novel mathematical approaches to optimization and equilibrium can provide effective tools in real-world contexts such as machine learning, network analysis, energy markets, finance, and transportation systems. By bridging theory and practice, the session encourages contributions that not only deepen the understanding of complex systems but also offer tangible solutions to current challenges.

Monotonicity of equilibria in nonatomic congestion games

Schedule: July 6 17:00-17:30 Room 316

Valerio Dose

Sapienza University of Rome, Italy

Co-Author(s): Roberto Cominetti, Valerio Dose, Marco Scarsini

Abstract:

Equilibria in nonatomic congestion games model how traffic distributes across resources when independent agents seek to minimize their own delays. While one might expect increased demand to uniformly increase resource usage, paradoxical non-monotone behavior is a well-documented phenomenon. In this talk, we investigate the monotonicity of equilibrium loads and costs as functions of total demand. In the classic case of single-commodity routing, it is known that network topology alone dictates these paradoxes. However, with multiple commodities, the combinatorial structure of strategy sets also plays an important role. We first demonstrate that singleton congestion games maintain monotone equilibrium loads with respect to any demand. We then extend this result to a broader class of multi-commodity games, which we define as Constrained Series-Parallel (CSP) games. Finally, we show that CSP games can be represented as variant of multi-commodity routing games on series-parallel networks, bridging the gap between abstract strategy sets and physical network topology.

Ghost penalties and stochastic programming

Schedule: July 6 15:00-15:30 Room 316

Francisco Facchinei

University of Rome La Sapienza, Italy

Abstract:

After recalling some recent results on ghost penalties, we discuss how this approach to constrained optimization can be used to develop new convergence results in stochastic programming. We cover the fully general case where both the objective function and the inequality constraints are non convex expected value functions.

Advances on Strong Duality Theory: Necessary and Sufficient Conditions and Applications

Schedule: July 6 15:30-16:00 Room 316

Sofia Giuffrè

University of Reggio Calabria, Italy

Co-Author(s): Antonino Maugeri, Attilio Marciano

Abstract:

Aim of the talk is to discuss and refine strong duality theory in infinite-dimensional settings. In particular, we deal with three constraint qualification conditions, Assumption S, Assumption S', and Condition NES, which are necessary and sufficient conditions for strong duality, highlighting their relationship with the saddle points of the Lagrange functional and the equivalence with a global optimization problem. Moreover, these assumptions prove to be very useful in many applications. Indeed, many equilibrium problems may be expressed in terms of variational or quasi-variational inequalities, in which these assumptions work. In the talk, in particular, we apply strong duality theory to the existence of Lagrange multipliers in the difficult partial differential equations setting of non-constant gradient constrained problem.

Toward an Integrated Reduced Order Modeling Framework for Inverse Problems in Linear Elasticity: A Preliminary Study

Schedule: July 6 16:30-17:00 Room 316

Basca Jadamba

Rochester Institute of Technology, USA

Co-Author(s): Basca Jadamba and Yidan Yang

Abstract:

The solution of coefficient inverse problems in partial differential equations (PDEs) remains a significant computational challenge, particularly in the context of linear elasticity where the vector-valued state variable and the high dimensionality of the parameter space result in substantial computational costs. This talk presents an exploratory framework for accelerating the estimation of the shear modulus (μ) in nearly incompressible media by leveraging Reduced Order Modeling (ROM) techniques. While ROM is traditionally applied to accelerate forward simulations, its integration into the optimization loop for inverse problems requires careful alignment between the reduced basis and the trajectory of the optimizer. We discuss an initial approach using Proper Orthogonal Decomposition (POD) to construct a reduced basis for the forward and adjoint operators within a gradient-based optimization routine. Preliminary results comparing the efficiency and reconstruction accuracy of this reduced-order approach for scalar elliptic problems are presented. An ongoing extension of this framework to the nearly incompressible elasticity equations will be discussed. This work represents an initial attempt to move toward a more goal-oriented ROM strategy where the reduced basis is informed by the requirements of the inversion process.

An Augmented Lagrangian Framework for Stochastic Optimization: Applications to Optimal Control and Parameter Estimation

Schedule: July 6 14:00-14:30 Room 316

Akhtar A Khan

Rochester Institute of Technology, USA

Abstract:

Inversion and control of systems under uncertainty pose significant computational challenges, particularly in high-dimensional stochastic environments. In this talk, I will present a rigorous, end-to-end mathematical and computational framework for solving constrained stochastic optimization problems governed by linear operator equations with uncertain coefficients. We will begin by establishing the problem within the setting of Bochner spaces. By adopting a finite-dimensional noise (FDN) assumption, I will demonstrate how to transform the primary optimization problem into a regularized saddle-point framework via a continuous augmented Lagrangian. I will also share our convergence analysis for the discretized system using a finite-dimensional Galerkin approximation, proving that our discrete solutions reliably converge to the continuous minimizer. To address practical implementation, the second half of the talk will focus on a newly developed Uzawa-type iterative algorithm with guaranteed strong convergence. Finally, I will introduce a fully discrete computational framework utilizing tensor products of spatial and stochastic basis functions. By detailing the explicit assembly of parameter-dependent global block matrices and the derivation of closed-form block gradients and Hessians, this talk will highlight how we can successfully bridge the gap between high-level functional analysis and efficient, robust numerical implementation.

Trust and reputation systems in cloud data centers: a variational approach

Schedule: July 6 17:30-18:00 Room 316

Attilio Marciano`

University Mediterranea of Reggio Calabria, Italy

Abstract:

The aim of this talk is to present a novel equilibrium model based on trust and reputation mechanisms for the analysis of cloud data centers, namely physical or virtual infrastructures providing computing resources and services. In this framework, servers mutually evaluate each other with the objective of maximizing a performance measure defined as the difference between benefits and costs, expressed in terms of reputation. The reputation of each server is modeled as a weighted aggregation of the trust values it receives, where the weights depend on the distances among servers. A variational approach is adopted to characterize the equilibrium configuration of the system from the user perspective, and theoretical results on existence and uniqueness are discussed. Finally, numerical simulations are presented to illustrate and validate the model, together with a sensitivity analysis highlighting the impact of initial reputation levels and distance parameters on the resulting equilibrium

Competitive Dynamics and Trust Mechanisms in Crowdsourced Delivery Networks: An Uncertain Variational Equilibrium Approach

Schedule: July 6 14:30-15:00 Room 316

Laura Rosa Maria Scrimali
University of Catania, Italy

Abstract:

The exponential expansion of on-demand delivery services (Uber Eats, Deliveroo, Glovo) has introduced intricate market mechanisms where courier trustworthiness emerges as a pivotal yet ambiguous element. Newly onboarded couriers typically lack substantial track records; platform assessments depend heavily on perception rather than rigorous statistical validation; and reputation metrics remain vulnerable to malicious behavior. This research introduces an innovative competitive equilibrium model grounded in uncertain variational inequalities, in which courier reliability metrics are represented as uncertain variables within Liu's uncertainty framework. Couriers engage in spatial competition for zone assignments while satisfying probabilistic constraints that require minimum trustworthiness thresholds at predetermined confidence levels. Our analytical approach transforms these uncertain restrictions into their deterministic counterparts using inverse uncertainty distributions, subsequently expressing the Nash equilibrium solution as a variational inequality problem. Computational simulations demonstrate how entry barriers tied to reputation scores influence both equilibrium resource distribution and platform efficiency. The findings highlight that carefully tuned reliability thresholds combined with adaptive confidence-level adjustments serve as effective policy instruments for equitable market participation, yielding actionable insights for digital platform governance and economic regulation.

Special Session 48 : Recent Advances in Nonlinear PDEs and Inverse Problems

Organizer(s): Yi-Hsuan Lin , Yavar Kian , Mikko Salo

Introduction: This session will showcase the current trends, challenges, and breakthroughs in Nonlinear PDEs, Inverse Problems, and related topics. It will emphasize their various applications and scientific disciplines. The session aims to cover recent developments related to the existence, uniqueness, regularity properties, and inverse problems of nonlinear PDEs. We hope the participants will be inspired and exchange ideas for potential future cooperation.

An Inverse Problem for a Nonlinear Monodomain System

Schedule: July 6 16:30-17:00 Room 634

Andrea Aspri

Università degli Studi di Milano Statale, Italy

Co-Author(s): Elena Beretta, Elisa Francini, Dario Pierotti, Sergio Vessella

Abstract:

In this talk, I will discuss an inverse problem for the nonlinear monodomain system. After briefly recalling the well-posedness of the direct problem for a reaction--diffusion equation coupled with an ordinary differential equation in the presence of perfectly insulating regions, I will focus on the inverse question of determining such regions from partial boundary measurements. Under suitable assumptions on the conductivity tensor, the nonlinear ionic terms, and the initial activation, I will present a uniqueness result showing that a single partial measurement of the transmembrane potential is sufficient to identify the geometry and location of the insulating inclusion. The analysis relies on a reformulation of the problem as a parabolic integro-differential equation and combines regularity estimates, a three-cylinder inequality, and unique continuation arguments. The result provides a rigorous uniqueness theorem for a class of inverse problems associated with nonlinear coupled systems of PDE--ODE type.

Simultaneous Stable Determination of Quasilinear terms for Parabolic equations

Schedule: July 10 11:00-11:30 Room 619

Zi Him Jason Choy

Chinese University of Hong Kong, Hong Kong

Abstract:

We consider the inverse problem of simultaneously recovering two classes of quasilinear terms appearing in a parabolic equation from boundary measurements. It is motivated by several industrial and scientific applications, including problems of heat conduction and population dynamics, and we study the issue of stability. More precisely, we derive simultaneous Lipschitz and Hölder stability estimates for two separate classes of quasilinear terms. The analysis combines different arguments including the linearization technique with a novel construction of singular solutions and properties of solutions of parabolic equations with nonsmooth boundary conditions. This is a joint work with Dr. Yavar Kian.

Nonlocal Partial Regularity

Schedule: July 10 15:00-15:30 Room 619

Cristiana De Filippis

University of Parma, Italy

Co-Author(s): Giuseppe Mingione, Simon Nowak

Abstract:

The failure of De Giorgi-Nash theory in vectorial problems opens to the study of partial regularity, namely smoothness of solutions outside a negligible, singular set. This is a classical phenomenon for systems and harmonic maps. I'll give an account of recent advances on nonlinear integro-differential systems, with emphasis on the structure and size of the singular set of solutions. From recent, joint work with Giuseppe Mingione (Parma) and Simon Nowak (Bielefeld).

Stable Determination and Reconstruction of a Semilinear Term in a Parabolic Equation

Schedule: July 10 11:30-12:00 Room 619

Maolin Deng

The Chinese University of Hong Kong, Hong Kong

Co-Author(s): Jason Choy, Maolin Deng, Bangti Jin and Yavar Kian

Abstract:

In this work, we investigate the inverse problem of determining a semilinear term appearing in a nonlinear parabolic equation from the measurement of the conormal derivative on the boundary. We first establish a uniqueness result, showing that the nonlinear term is uniquely determined provided the difference between two candidates does not change sign infinitely many times. Subsequently, we derive Hölder-type stability estimates for the reconstruction, where the stability exponent depends explicitly on the number of sign changes of the difference between two admissible nonlinear terms. Improved stability estimates are obtained under higher regularity assumptions on the nonlinear term. Finally, we propose a numerical reconstruction algorithm based on an iterative scheme and validate its performance through various numerical experiments with noisy data.

Inverse Problems for Anisotropic Conductivities in Semilinear Models

Schedule: July 6 17:00-17:30 Room 634

Elisa Francini

Università di Firenze, Italy

Co-Author(s): Elena Beretta, Dario Pierotti, Eva Sincich

Abstract:

In this talk, we discuss an inverse boundary value problem arising in a semilinear elliptic model motivated by cardiac electrophysiology. The model describes the stationary behavior of the transmembrane potential under pacing and involves an anisotropic conductivity tensor together with a nonlinear ionic response. We address the problem of recovering a piecewise constant anisotropic conductivity from boundary measurements encoded by the Neumann-to-Dirichlet map. Assuming that the nonlinear coefficient and the geometry of the inclusion are known, we present a uniqueness result showing that the conductivity is uniquely determined by the boundary data. The analysis is based on a first-order linearization of the nonlinear map around a nontrivial background state, leading to a linear elliptic problem with a strictly positive zeroth-order term. This reduction allows us to combine boundary determination techniques for anisotropic conductivities with unique continuation arguments to achieve identifiability.

Uniqueness for the inverse spectral modified transmission eigenvalue problem for a piecewise continuous spherically symmetric refractive index

Schedule: July 10 14:00-14:30 Room 619

DROSSOS GINTIDES

NATIONAL TECHNICAL UNIVERSITY OF ATHENS, Greece

Co-Author(s): KYRIAKOS STRATOURLAS

Abstract:

We consider the uniqueness question for the inverse modified transmission eigenvalue problem from modified transmission eigenvalues. We assume that the refractive index is spherically symmetric and piecewise continuous. The corresponding direct spectral transmission problem refers to a system of two Helmholtz type equations in the same domain where the spectral parameter appears in the one equation, which corresponds to an artificial metamaterial. In addition, the two corresponding fields have equal Cauchy data on the boundary. By using separation of variables to describe the direct problem, we reconstruct the Dirichlet-to-Neumann map for the field that satisfies the Helmholtz equation with the refractive index $n(r)$. By utilizing well-known results from the Borg-Levinson theory for Schrodinger's equation we prove the uniqueness of the recovery of $n(r)$. We explore some special properties of the spectrum and present simple examples.

An inverse source problem for a quasilinear elliptic equation

Schedule: July 10 10:30-11:00 Room 619

Shubham Jaiswal

University of Jyväskylä, Finland

Co-Author(s): Tony Liimatainen

Abstract:

In this talk, we consider the inverse source problems for quasilinear elliptic equations of the form

$$\{ \nabla \cdot (\gamma(x, u, \nabla u) \nabla u) = F \quad \text{in } \Omega, \quad u = f \quad \text{on } \partial\Omega,$$

where $\Omega \subset \mathbb{R}^n$, $n \geq 2$, is a simply connected bounded domain. We consider the specific nonlinearity $\gamma(x, u, \nabla u) = \sigma(x) + q(x)u$, with q assumed to be known. By exploiting the nonlinearity to break the gauge invariance of the problem, we establish unique recovery of both σ and F from the associated Dirichlet-to-Neumann (DN) map under the structural conditions q and $\nabla(\sigma/q)$ are nowhere vanishing in $\overline{\Omega}$. In the absence of these conditions, in particular in the linear case, we demonstrate that the inverse problem admits a gauge obstructing the uniqueness. We use higher order linearizations to obtain a complicated coupled system for the unknowns. The complexity of this system arises in part from the gauge freedom of the linearized equation, which is new in this context. We solve the system by constructing suitable complex geometric optics solutions and applying the unique continuation principle for nonlinear elliptic systems. We anticipate that the solution method developed here will prove useful in other inverse problems as well. This is a joint work with Tony Liimatainen.

Recovery of nonlinear material parameters in a quasilinear Lamé system

Schedule: July 10 9:00-9:30 Room 619

David Johansson

Aarhus University, Denmark

Co-Author(s): Yavar Kian

Abstract:

I will discuss the identifiability of a nonlinear tensor in a quasilinear elliptic system, which is inspired by elasticity theory. As measurements we use point measurements at finitely many boundary points of the conormal derivative (or traction) of solutions generated by Dirichlet data (or boundary displacement) in the space of first order polynomials. By a linearization argument, we show that this data uniquely determines a nonlinear but space-independent tensor. Measurements in a single point is sufficient in the case of an isotropic tensor, while several points are used in the anisotropic case.

Extension of the Boundary Control Method to Elliptic and Parabolic Problems, with Applications to the Calderón Problem

Schedule: July 10 14:30-15:00 Room 619

Dimitra Kyriakopoulou

Biomedical Research Foundation Academy of Athens, Greece

Abstract:

We extend the Boundary Control method beyond the hyperbolic setting to certain elliptic and parabolic inverse boundary value problems. The analytic framework is based on Schulze's edge calculus, with the parabolic case reduced to an elliptic problem. The reconstruction step is formulated through Boundary Control algebras generated by boundary-induced solutions. Under suitable separation assumptions, these algebras recover the underlying manifold, or in the parabolic case a compact spacetime strip, as a Gelfand spectrum. We then discuss applications to the Calderón problem. In dimension $n \geq 3$, this gives a real-analytic conductivity-metric result, while in dimension two it yields a Boundary Control approach based on holomorphic trace algebras and recovery up to the natural conformal gauge. We also outline an ongoing attempt to treat the higher-dimensional smooth anisotropic case within the same framework.

An inverse problem for the prescribed mean curvature equation

Schedule: July 6 18:00-18:30 Room 634

Janne Nurminen

University of Jyväskylä, Finland

Co-Author(s): Tony Liimatainen

Abstract:

In this talk I will formulate an inverse source problem for the prescribed mean curvature equation (PMC)
$$-\nabla \cdot \left[\frac{\nabla u}{\sqrt{1+|\nabla u|^2}} \right] = H(x) \quad \text{in } \Omega$$
 for a smooth bounded set $\Omega \subset \mathbb{R}^2$. The question is if from measurements done on the boundary $\partial\Omega$ one can determine the mean curvature H in Ω . The talk is based on joint work with Tony Liimatainen (<https://arxiv.org/abs/2509.22078>) and we show that it is indeed possible to recover H . The proof relies on the higher order linearization method and asymptotical analysis in an integral identity using complex geometric optics solutions from the work of Guillarmou and Tzou in 2011.

Interior decay of solutions to elliptic equations and applications to inverse problems

Schedule: July 10 8:30-9:00 Room 619

Luca Rondi

Università degli Studi di Pavia, Italy

Abstract:

We investigate the decay in the interior of solutions to elliptic equations with respect to the boundary data. In particular, the decay rate is linked to the so-called frequency of the boundary datum and is in general stronger when coefficients are smoother. We show applications of these decay results to the electrical impedance tomography. A key ingredient in the proof is to study the distance function from the boundary for a Riemannian manifold. We show that, up to a conformal change of the metric, it coincides with the distance in the Euclidean case, thus inheriting its regularity properties.

Inverse problems for quasi-linear elliptic systems modeling electrolyzers

Schedule: July 6 17:30-18:00 Room 634

Matteo Santacesaria

University of Genoa, Italy

Co-Author(s): G.S. Alberti, W. Gerner

Abstract:

Optimizing electrolyser cells for green hydrogen production requires a precise understanding of their internal electrochemical processes. We model these dynamics using a coupled system of quasi-linear elliptic PDEs and investigate the inverse problem of reconstructing non-linear diffusion coefficients and electric potential relations. In this talk, I will show that boundary measurements alone are insufficient for unique reconstruction. By generalizing a known linearization technique to systems with non-local nonlinearities, we prove that combining boundary and interior measurements resolves this issue. I will outline the mathematical framework and explain why interior data is the essential key to freezing the coefficients and successfully solving the inverse problem.

Inverse scattering problems for nonlinear wave equations on Lorentzian manifolds

Schedule: July 10 8:00-8:30 Room 619

Teemu Tyni

University of Oulu, Finland

Co-Author(s): Spyros Alexakis, Hiroshi Isozaki, Matti Lassas

Abstract:

We discuss some recent results on inverse scattering problems for semi-linear wave equations. The inverse scattering problem is formulated on a Lorentzian manifold equipped with a Minkowski type infinity. We show that a scattering functional, which roughly speaking maps measurements of solutions of a semi-linear wave equation at the past infinity to the future infinity, determines the manifold, the conformal class of the metric, and the nonlinear potential function up to a gauge. The main tools we employ are a Penrose-type conformal compactification of the Lorentzian manifold, reduction of the scattering problem to the study of the source-to-solution operator, and the use of higher order linearization method to exploit the nonlinearity of the wave equation. This is a joint work with S. Alexakis, H. Isozaki, and M. Lassas.

Boundary regularity for nonlocal equations

Schedule: July 10 9:30-10:00 Room 619

Marvin Weidner

University of Bonn, Germany

Co-Author(s): Serena Dipierro, Xavier Ros-Oton, Enrico Valdinoci

Abstract:

The boundary behavior for solutions to nonlocal equations with exterior Dirichlet boundary conditions has been extensively studied in recent years and it is well known that, in general, s -harmonic functions are not better than C^s . In contrast, the Neumann problem for nonlocal equations has received much less attention, and the optimal boundary regularity of solutions remains unknown. In this talk, I will present recent progress on this question, based on a new classification result for solutions to general nonlocal equations in 1D. This is joint work with Serena Dipierro, Xavier Ros-Oton, and Enrico Valdinoci.

Generic regularity of the free boundary in the Alt-Caffarelli-Phillips problem

Schedule: July 6 17:30-18:00 Room 634

Hui Yu

National University of Singapore, Singapore

Co-Author(s): Xavier Fernandez-Real

Abstract:

For generic boundary data, we discuss an improvement of the estimate of the singular dimension in the Alt-Caffarelli-Phillips problem.

Special Session 49 : Nonlinear Waves in Discrete Systems

Organizer(s): Baofeng Feng , Panayotis Kevrekidis , Georgios Theocharis

Introduction: The study of nonlinear waves in discrete systems has witnessed significant developments in recent years, with applications spanning nonlinear optics, atomic physics, and metamaterials, among numerous others. This session aims to bring together experts investigating the unique features of discrete nonlinear wave models, including but not limited to the existence, stability and dynamics of discrete solitons and breathers, discrete shock waves, modulational and transverse instabilities, topological and non-Hermitian features and thermodynamic properties. We plan to invite contributions that will explore analytical, numerical, and experimental perspectives, as well as connections to continuum limits, integrability, and novel computational approaches (including scientific Machine Learning ones). Some among the many models of interest include discrete nonlinear Schrödinger equations, Klein-Gordon and Fermi-Pasta-Ulam-Tsingou chains, long-range lattices, and tight-binding or lumped-element models that capture the nonlinear wave propagation in metamaterials. By fostering discussions among researchers working on these diverse yet interconnected themes, this session seeks to advance our understanding of discrete nonlinear wave dynamics and identify new directions for future research. We thus hope that it will be of interest to junior and more seasoned researchers alike.

Nonlinearity and Nonreciprocity: Edge States, Wave Dynamics, and Solitons

Schedule: July 9 17:30-18:00 Room 425

Vassos Achilleos

CNRS-LAUM, France

Abstract:

We present results on the interplay between nonlinearity, nonreciprocity, and topology in non-Hermitian lattices. We demonstrate that nonreciprocal topological lattices support insensitive edge states whose spectral properties remain immune to symmetry-breaking nonlinear perturbations, due to a competition between nonlinear self-interactions and mode nonorthogonality. We then analyze bulk wave-packet dynamics in the nonlinear Hatano-Nelson model, identifying three successive regimes driven by nonreciprocal amplification, and derive analytical predictions showing that nonlinearity modifies both the magnitude and time dependence of wave-packet acceleration. Finally, we show that nonlinearity enables unidirectional soliton formation in active nonreciprocal lattices, demonstrated analytically and experimentally in an active electrical transmission line.

Spectral Precursors of Rogue-Wave Cascades across the Salerno Deformation

Schedule: July 9 18:00-18:30 Room 425

Jimmie Adriaola

Arizona State University, USA

Abstract:

We study higher-order rogue waves and multi-generation cascades on the Salerno lattice. The model interpolates between integrable Ablowitz-Ladik and DNLS, and we generate cascades from Thomas-Fermi quench data. In the integrable periodic case, rogue waves come from spectral degeneracies at band endpoints on modulationally unstable arcs. We ask whether similar degeneracies continue to organize cascade formation once integrability is broken. The work has two parts. On the lattice, we compute Floquet and Lax spectral portraits of TF data along the Salerno deformation, looking for branch crossings and arc reconnections that precede focusing events. In the continuum limit, we use the Madelung transform and Whitham modulation to track dispersionless focusing, gradient catastrophe, and the onset of oscillations. The goal is a single picture connecting continuum modulation to lattice spectral geometry.

Enabling inverse design of mechanical nonlinear waves

Schedule: July 9 16:30-17:00 Room 425

Nicholas Boechler

University of California San Diego, USA

Abstract:

In this talk, I will review our recent progress on enabling the ability to answer, within a mechanical context: "For this dynamical application, what is the best nonlinear elastic constitutive response I could choose?" and, given that, "How can I achieve that nonlinearity?" Using an 1D, FPUT-like chain, we conduct an inverse design algorithm to find polynomial nonlinear springs that optimize, separately, the minimization of peak kinetic energy experienced in response to impact, and a prescribed displacement path executed, both evaluated at the opposite end of the chain. We then show how a second inverse design algorithm can be used to identify solid elastic springs that leverage geometric nonlinearity to achieve the targeted spring law. Simulation and experiment results are compared. Future extensions to irreversible contexts, higher dimensions, and mechanical neural networks will be discussed.

Can Breathers Survive? Instability and Control in Periodic Optical Media

Schedule: July 9 17:00-17:30 Room 425

Martina Chirilus-Bruckner

Leiden University, Netherlands

Abstract:

Motivated by the quest to develop optical storage, we investigate the formation and persistence of breathers in materials with periodically varying properties in the presence of randomness, noise, and damping. A particular focus is on whether appropriately chosen forcing can extend the lifetime of these long-lived structures. Our work builds on the rigorous construction of breathers for a Klein-Gordon equation with periodically varying coefficients and is further motivated by recent results suggesting that such breathers are typically unstable. In this presentation, we explore the extent to which randomness, noise, damping, and forcing can mitigate, delay, or even counteract this instability. Since their stability is notoriously difficult to address analytically, numerical stability analysis is essential. At the same time, the resulting numerical schemes naturally lead to lattice equations whose relationship to the underlying continuum description is rather delicate.

Breather solutions to the coupled Ablowitz-Ladik lattice equations

Schedule: July 10 10:30-11:00 Room 425

Baofeng Feng

University of Texas Rio Grande Valley, USA

Abstract:

We present our recent results on general breather solutions to the coupled Ablowitz-Ladik (cAL) lattice equations in terms of pfaffians. We first bilinearize the cAL lattice equations into a set of three bilinear equations under nonzero plane wave background. We show that the first two bilinear equations can be derived from the discrete BKP equation through Miwa transformation, while the third one can only be approved via the identities of pfaffians. In the second part, we will present dynamical behaviors of one-, two-breather solutions. It is interesting that a type of resonant breather solutions exists in the cAL lattice equations which seems new in the literature.

Superconducting oscillators: From collective behavior to Reservoir Computing

Schedule: July 9 18:30-19:00 Room 425

Johanne Hizanidis

Foundation for Research and Technology, Greece

Abstract:

In ensembles of coupled oscillators, the synergy between topological features and the underlying dynamics may lead to interesting self-organized phenomena. In the first part of my talk, I will present a system that is capable of exhibiting such complex dynamics: a SQUID (superconducting quantum-interference device) metamaterial, i. e. an artificially structured medium of periodically arranged, weakly coupled SQUIDs, which shows extraordinary electromagnetic properties and tunability. From a dynamical point of view, the single SQUID is a highly nonlinear system exhibiting extreme multistability and chaos. I will talk about the emergent collective behavior in SQUID metamaterials, in particular spatiotemporal pattern formation and chimera states. The fundamental building block of superconducting devices is the Josephson junction (JJ), which inherently exhibits neuromorphic properties and can mimic basic neuron-like behavior. Superconductor-based neuromorphic systems are particularly attractive because they combine ultrafast operation, approaching terahertz frequencies, with extremely low, sometimes negligible, power dissipation. In the second part of my talk, I explore how Josephson junctions can serve as physical substrates for machine learning, focusing on reservoir computing applications. In particular, we investigate time-multiplexed reservoir computing, which exploits the strong nonlinearity and rich dynamical response of Josephson junctions to perform information processing tasks efficiently.

Discrete Nonlinear Schrödinger versus Ablowitz-Ladik: Existence and dynamics of NLS-type lattices over a nonzero background

Schedule: July 10 8:30-9:00 Room 425

Nikos I Karachalios

Department of Mathematics, University of Thessaly, Greece

Co-Author(s): Dirk Hennig, Dionyssios Mantzavinos and Dimitrios Mitsotakis

Abstract:

We will discuss the local well-posedness for Ablowitz-Ladik (AL) and Discrete Nonlinear Schrödinger (DNLS) equations supplemented with a broad class of nonzero boundary conditions and, in addition, derive analytical upper bounds for the minimal guaranteed lifespan of their solutions. These bounds suggest finite-time collapse (blow-up) of solutions in the case of the AL systems and the phenomenon of quasi-collapse in the case of DNLS systems. Numerical simulations confirm another theoretical result on the proximity of the dynamics between the two models over time scales up to the common solution lifespan. Finally, for power nonlinearities, we prove the asymptotic equivalence between the two discrete models in the continuous limit.

Wavepacket Modulation in Nonlinear Lattices: Nonlinear Schrodinger Formalism and Application in Dusty Plasma Crystals

Schedule: July 10 9:30-10:00 Room 425

Ioannis Kourakis

Khalifa University of Science and Technology, United Arab Emirates

Co-Author(s): Ioannis Kourakis, Aysha Nihidha Pulakkal, Mehnaz Gafoor, Hadi Susanto, Nick Lazarides

Abstract:

This study focuses on the modulational dynamics of wave packets propagating in a one-dimensional (1D) hybrid Fermi-Pasta-Ulam-Tsingou / Klein-Gordon (FPUT-KG) type lattice chain, incorporating an arbitrary polynomial coupling potential anharmonicity combined with the presence of a nonlinear on-site (substrate) potential. Applying Newell's multiple scales method, we have derived a Nonlinear Schrodinger type equation (NLSE) and thus obtained analytical expressions for the dispersion and nonlinearity coefficients, in terms of the carrier wavenumber k and the intrinsic lattice configuration parameters. We have explored the conditions for different regimes to occur, in order to determine the type of envelope soliton solutions to be sustained. The analysis is extended to different types of coupling anharmonicity and onsite potential nonlinearity, offering insight into the interplay between these factors and the system's dynamical behavior. We have focused in particular on extreme amplitude envelope modes (freak waves), e.g. of the Peregrine soliton type, and on their dependence on the various intrinsic system parameter values [1]. Our results are relevant in various contexts where periodic systems (e.g. crystals) may occur. As a novel field of application, this research applies to the modeling of dust-lattice waves in dusty plasma crystals. The substrate potential in this case is provided by electrostatic trapping in laboratory experiments, in combination with gravity, while the inter-site interaction potential is essentially of Debye-Hueckel type. This relation will be briefly discussed, and some preliminary results will be presented [2]. [1] Aysha Nihidha Pulakkal et al, in preparation (2026). [2] I. Kourakis & P. K. Shukla, Int. J. Bifurcation & Chaos 16, 1711 (2006).

Exponential asymptotics for calculating stability in discrete NLS equations

Schedule: July 10 8:00-8:30 Room 425

Christopher Lustri

The University of Sydney, Australia

Co-Author(s): Panos Kevrekidis, Jon Chapman, Ines Aniceto

Abstract:

Exponential asymptotics can be used to calculate exponentially small asymptotic contributions in singularly-perturbed problems. I will apply these techniques to determine the behaviour of breathers in the discrete nonlinear Schrödinger equation. I will begin by demonstrating how these ideas predict the well-known feature of the existence of two types of fixed points, namely site-centered and inter-site-centered. I will then show that the exponentially small contributions to the solution can be used to calculate the asymptotic scaling and precise value of the exponentially small eigenvalues in the system associated with site-centered (stable) and inter-site-centered (unstable) configurations. I will then explain how this method can be extended to study related problems, such as the dynamics of kink solutions and solutions with long-range dependence. This method paves the way for such an analysis in a wide range of lattice nonlinear dynamical equation models.

Geometry Meets Computation: Localized States in DNLS Lattices with Extended Interactions

Schedule: July 10 9:00-9:30 Room 425

VASSILIOS M ROTHOS

Aristotle University of Thessaloniki, Greece

Abstract:

Localized wave phenomena in discrete nonlinear Schrodinger (DNLS) lattices play a central role in applications ranging from nonlinear optics to energy transport in complex media. In such systems, the interplay between nonlinearity, discreteness, and extended interactions gives rise to rich families of spatially localized states, commonly referred to as discrete solitons. In this talk, we revisit the existence of stationary localized waves in DNLS lattices with non-nearest neighbour interactions from a dynamical systems perspective. Building on recent results, where such structures are constructed via invariant manifold techniques and homoclinic dynamics, we highlight the geometric mechanisms underlying their formation and organization. We then introduce a complementary computational approach aimed at promoting high-accuracy numerical approximations to mathematically reliable solutions. Without entering into technical details, we outline how modern validation techniques can be used to rigorously certify the existence of localized states while providing quantitative control of approximation errors. The combined geometric and computational viewpoint offers a flexible framework for the analysis of nonlinear lattice models and opens the way to the systematic validation of localized wave phenomena in discrete media.

Special Session 50 : Dynamical systems: Oseledets decomposition, ordered spaces, Lyapunov exponents, and applications

Organizer(s): Janusz Mierczyński , Marek Kryspin

Introduction: The main subject of the session are linear skew-product dynamical systems, including but not limited to those generated by differential equations of various types. We wish to bring together experts on those topics, from those dealing with the fundamental questions of existence, to interactions between Oseledets decompositions/Lyapunov exponents and other structures preserved by the system, as order relations, etc., as well as Oseledets decompositions on different fibres, to applications in the investigation of differential equations and related topics.

Loss of hyperbolicity as a source of critical transitions in d-concave equations: New nonautonomous bifurcation patterns

Schedule: July 9 17:00-17:30 Room 301

Jesús J. Diez

Universidad de Valladolid, Spain

Co-Author(s): Carmen Núñez and Rafael Obaya

Abstract:

This talk introduces bifurcation scenarios in nonautonomous scalar ordinary differential equations whose derivative with respect to the state variable is concave in measure (so-called d-concave equations). Leveraging the strong constraints that d-concavity imposes on the global dynamics, we describe bifurcation patterns that, to the best of our knowledge, have not been reported previously. In particular, using a minimal but multiply ergodic skewproduct base, we construct an example of a jump bifurcation in which two nonhyperbolic compact invariant sets coexist, and each one disappears abruptly under parameter variation--one for each of the two possible directions of change. The study of such phenomena is motivated by critical transition theory, where small perturbations in the inputs of a complex system can trigger sudden and often irreversible shifts in its response. The nonautonomous bifurcations presented here provide a potential mechanism for critical transitions distinct from the better-studied saddle-node bifurcations.

Quenched extreme value theory and hitting-time distributions for random dynamical systems via spectral perturbation of transfer operator cocycles

Schedule: July 9 9:00-9:30 Room 301

Gary Froyland

UNSW Sydney, Australia

Co-Author(s): Jason Atnip, Cecilia Gonzalez-Tokman, Sandro Vaienti

Abstract:

I will describe work in a program to extract statistical properties of random dynamical systems using spectral approaches based on transfer operator cocycles and Lyapunov exponents. A random dynamical system is governed by a cocycle of nonlinear transformations on a state space and this naturally induces a cocycle of linear transfer operators acting on suitable Banach spaces. By using random perturbation theory to study derivatives of Lyapunov exponents of ``twisted`` transfer operator cocycles, we obtain elegant proofs of statistical limit laws such as a central limit theorem. Inserting random holes into the phase space, we produce a nonstationary extreme value theory for a random observation function, whereby observing an extreme value corresponds to landing in a random hole and terminating the trajectory. Considering the holes as ``targets``, we further extend this formalism to count the number of visits to random targets in a random orbit, thereby capturing the counting distribution of extreme-value occurrences in random trajectories of increasing length. All results are in the ``quenched`` sense, meaning that they hold almost surely across all random realisations of the dynamics and observations.

Lyapunov--Oseledets spectrum for transfer operator cocycles under perturbations

Schedule: July 9 8:30-9:00 Room 301

Cecilia Gonzalez-Tokman

University of Queensland, Australia

Co-Author(s): Anthony Quas

Abstract:

Random dynamical systems provide useful and flexible models to investigate systems whose evolution depends on external factors, such as noise and seasonal forcing. In recent years, the study of transfer operators has been combined with multiplicative ergodic theory to shed light on ergodic-theoretic properties of such systems. The so-called Lyapunov--Oseledets spectrum associated to the transfer operator cocycle contains fundamental information about invariant measures, exponential decay rates and coherent structures which characterize dominant global transport features of the system. While the scope of this framework is broad, it is often challenging to identify and approximate this spectrum. In this talk, we present examples of random maps where the Lyapunov--Oseledets spectrum can be understood and analyzed under perturbations.

On the Invariance of Dynamics under Continuous Embeddings

Schedule: July 9 14:30-15:00 Room 301

Marek Kryspin

Wroclaw University of Science and Technology, Poland

Abstract:

The multiplicative ergodic theorem (the Oseledets theorem), the Folquet theorem and exponential separation are related results concerning the decomposition of the phase space (more generally, of fiber bundles) on which a dynamical system acts. This decomposition is based on the system's dynamics and exponential growth rates (Lyapunov exponents). Sometimes, when the dynamical system arises from differential equations, it may happen that after some time the associated mappings transfer elements from a Banach space X into a (better) space Y , continuously embedded in the former. This occurs, for instance, in parabolic problems, in which an irregular initial condition becomes a smooth function, or for delay differential equations, in which an initial function of class L_p becomes, after some time, continuous (and even absolutely continuous, hence differentiable almost everywhere). We will show that, on the embedded space, the dynamics of the system remains the same

Nonautonomous saddle-node bifurcations and early warning signals in scalar concave and d-concave differential equations

Schedule: July 9 17:30-18:00 Room 301

Iacopo P. Longo

University of Exeter, England

Co-Author(s): Jesus Duenas, Rafael Obaya

Abstract:

We characterise the range of possible dynamical behaviours for scalar concave and d-concave nonautonomous differential equations, and demonstrate that nonautonomous saddle-node bifurcations provide a universal mechanism underlying certain critical transitions known as rate-induced tipping. Furthermore, we establish that finite-time Lyapunov exponents serve as reliable and rigorous early warning indicators of such transitions in these systems, as a change in sign occurs prior to the onset of a nonautonomous saddle-node bifurcation.

Oseledets decomposition and monotone dynamical systems

Schedule: July 9 15:00-15:30 Room 301

Janusz Mierczyński

Wrocław University of Science and Technology, Poland

Abstract:

The Oseledets theory gives an invariant decomposition of a skew-product linear dynamical system into measurable subbundles according to Lyapunov exponents, that is, exponential growth rates of orbits. On the other hand, when the fibers are ordered by a cone and the dynamical system satisfies some monotonicity condition, there is an invariant decomposition into a subbundle consisting of orbits that are always positive and negative and its complementary subbundle. It is an interesting topic to investigate relations between those two approaches.

On linearized stability

Schedule: July 9 8:00-8:30 Room 301

Christian Poetzsche

University of Klagenfurt, Austria

Co-Author(s): Nestor Jara (University of Chile, Santiago, Chile)

Abstract:

The role of dynamical spectra (based on Lyapunov exponents or exponential dichotomies) is to substitute eigenvalues in a time-variant framework. In doing so, such spectra indicate stability by linearizing along a reference solution and applying a suitable principle of linearized stability. We discuss related principles in the light of recent spectral notions that describe non-exponential growth/decay.

Invariant manifolds induced by stochastic delay differential equations

Schedule: July 9 9:30-10:00 Room 301

Sebastian Riedel

FernUniversitaet Hagen, Germany

Co-Author(s): Mazyar Ghani Varzaneh, Michael Scheutzow

Abstract:

Stochastic delay differential equations (SDDEs) can be understood as a class of stochastic evolution equations on infinite-dimensional (path) spaces. As observed by S.-E. A. Mohammed in 1986, these equations do not necessarily induce a stochastic flow. Consequently, they do not induce a random dynamical system (RDS) on a deterministic path space. Together with M. Ghani Varzaneh and M. Scheutzow, we observed that these equations still induce RDS if we allow the spaces themselves to be random. More precisely, we were able to show that SDDEs induce RDS acting on a particular field of Banach spaces. It turns out that these RDS still have a rich structure that, for example, allows one to deduce the existence of invariant manifolds. In this talk, we explain why it is necessary to study random dynamical systems on fields of Banach spaces when analyzing the dynamics of SDDEs, and discuss our latest results on this topic.

A new class of generalized ordinary differential equations

Schedule: July 9 16:30-17:00 Room 301

Ana M Sanz

Universidad de Valladolid, Spain

Co-Author(s): Sylvia Novo and Rafael Obaya

Abstract:

In this talk, we present a new class of generalized ordinary differential equations. Our motivation arises from the fact that solutions of limiting equations associated with certain Carathéodory ODEs may lose the property of absolute continuity, while remaining continuous and of bounded variation on compact intervals. Several approaches can be employed to address these irregular limiting equations. We propose a novel method, based on the introduction of a class of generalized ODEs given by parametric b -measures, aimed at preserving the aforementioned properties of solutions for the equations in the hull, as well as ensuring the compactness of the hull. This framework allows us to apply techniques from nonautonomous dynamical systems to the study of precompact families of Carathéodory ODEs.

Existence, uniqueness, and stability of monotone traveling waves for repulsion chemotaxis systems with logistic type source

Schedule: July 9 13:30-14:00 Room 301

Wenxian Shen

Auburn University, USA

Abstract:

This talk is concerned with the existence, uniqueness, and stability of traveling wave solutions to a repulsion parabolic-elliptic chemotaxis system with logistic type source. When the chemotaxis sensitivity coefficient $\chi = 0$, this system reduces to the so called Fisher-KPP equation, which generates a monotone dynamical system, possesses a minimal wave speed c^* , and admits a unique monotone stable traveling wave solution connecting the positive constant solution and the zero solution for any speed $c \geq c^*$. When $\chi \neq 0$, the system does not generate a monotone dynamical system, or comparison principle does not hold for the system, and several difficulties appear when studying traveling wave solutions to the system. In this talk, we will show that when χc^* such that the system admits a unique stable monotone traveling wave solution connecting the positive constant solution and the zero solution for any speed $c > \chi^*$. Though the comparison principle does not hold for the system, it is utilized in some nontrivial way in the proof of the results stated in the above.

C^1 -theory for smooth non-autonomous monotone dynamical systems

Schedule: July 9 18:00-18:30 Room 301

Yi Wang

University of Science and Technology of China, Peoples Rep of China

Co-Author(s): Jinxiang Yao

Abstract:

In this talk, we will report the C^1 -theory and its recent progress on smooth non-autonomous monotone dynamical systems. This talk is based on a series of joint works with Jinxiang Yao.

Measurably dominated splitting of fields of Banach spaces

Schedule: July 9 14:00-14:30 Room 301

Caibin Zeng

South China University of Technology, Peoples Rep of China

Co-Author(s): Huayan Su

Abstract:

In this talk, we establish a quasi-equivalence between measurably contracting cone families and measurably dominated splittings in measurable fields of Banach spaces. Under an integrability condition, we obtain a generalized Krein-Rutman-type theorem for compact, injective linear cocycles on Banach spaces, without requiring the cocycle itself to be compact or integrable.

Special Session 51 : Recent progress on the rogue waves and their applications

Organizer(s): Jinbing Chen , Liming Ling , Bo Yang

Introduction: Rogue waves are spatial-temporal localized perturbations characterized by large amplitudes that seemingly emerge from nowhere and vanish without a trace. These wave patterns are known to occur in deep fluids and nonlinear optics. This session is dedicated to discussions on recent advancements in the analytical, numerical, and experimental studies of rogue waves and their applications. Topics will include, but are not limited to, spectral stability, modulational instability, representations of rogue waves, wave patterns and dynamics, as well as numerical simulations and their applications. Our primary objective is to bring together researchers from various fields related to rogue waves to present their latest findings, exchange ideas, and foster new collaborations.

Numerical simulations of nonlinear evolution of modulational instabilities of Short-Crested Waves

Schedule: July 8 8:30-9:00 Room 640

Malek ABID

Aix-Marseille Université/IRPHE, France

Co-Author(s): Marc Francius, and Christian Kharif

Abstract:

Understanding the formation of extreme waves in crossing seas remains a major challenge in ocean physics. In this work, we investigate the modulational instability of short-crested waves (SCWs), a fundamental mechanism through which energy localizes and potentially leads to rogue waves. Using the coupled nonlinear Schrödinger (CNLS) framework, we analyze how crossing angle and perturbation direction control the nature of unstable modes. A key result is the first explicit link between CNLS instability predictions and the resonance-based classification (Ia/Ib) derived from fully nonlinear theory. Through systematic numerical simulations, complemented by fully nonlinear Euler computations using a High-Order Spectral Method, we show that a single perturbation can trigger markedly different dynamical responses, including self-phase and cross-phase instabilities. These findings reveal strong sensitivity of instability growth and wave amplification to wave geometry. While the CNLS model provides an efficient and accurate description of early-stage dynamics, fully nonlinear effects become essential to capture long-term evolution and extreme wave amplification.

Onset of instability for the Alber equation, and applications for rogue waves

Schedule: July 8 9:00-9:30 Room 640

Agissilaos G Athanassoulis

University of Dundee, Scotland

Co-Author(s): Irene Kyza

Abstract:

The Alber equation has been long used as a statistical model for ocean waves. Its bifurcation between a linearly stable and linearly unstable regime have long been linked with rogue waves. However, the nature of this bifurcation in the fully nonlinear problem (as opposed to the linearized one) has been much less understood. In this work, we use numerical simulation to explore that question. First of all, we focus on the lengthscales of the problem, as too short a computational domain can artificially suppress the instability. We show that, in the stable case, there is nonlinear Landau damping in the fully nonlinear problem. Moreover, we verify that inhomogeneities do start to grow exponentially in the unstable regime -- but, for intermediate intensities, their maxima plateau at values negligible with regard to the background. Thus, the presence of linear instability does not guarantee the appearance of localized maxima. A second bifurcation is observed, when the instability becomes large enough and localized extreme events are formed. Monte Carlo investigation shows that the qualitative behavior of the inhomogeneity depends only on the background spectrum, and not on the initial inhomogeneity.

Periodic waves in the Jaulent--Miodek equation: modulational stability and algebraic solitons

Schedule: July 8 16:30-17:00 Room 640

Jinbing Chen

Southeast University, Peoples Rep of China

Co-Author(s): Zhihang Gu

Abstract:

We study the finite-dimensional integrable reduction for the Jaulent--Miodek (JM) equation associated with the energy-dependent Schrödinger operator, in which a traveling periodic wave expressed by Jacobi elliptic functions is obtained for the JM equation. Solutions of the linearized JM equation are represented as squared eigenfunctions of the Lax system, so that the stability spectrum are connected with the Lax spectrum via a characteristic polynomial. The Lax spectrum are numerically computed by using the Floquet--Bloch decomposition of periodic solutions of Lax system, while the stability spectrum are traced out via the characteristic polynomial. Since the band of stability spectrum lies on the imaginary axis, the traveling periodic wave of JM equation is proved to be modulationally stable. Followed by a gauge transformation, the Darboux transformation is retrieved in a different way, from which a new algebraic soliton is obtained at the endpoint of continuous spectral band, and three new periodic waves are derived with three discrete eigenvalues.

Smooth soliton solutions of the Camasssa-Holm type equations

Schedule: July 8 15:30-16:00 Room 640

Nianhua Li

Huaqiao University, Peoples Rep of China

Abstract:

We will present some new results on integrable systems of Camassa-Holm (CH) type. First, we will provide a nearly complete list of (1+1)-dimensional CH-type equations and propose several new extensions, including super and (2+1)-dimensional generalizations. Next, we will discuss their integrability properties and exact solutions. Finally, taking the modified CH equation as an example, we shall show how to construct smooth soliton solutions of the CH type equations by an approach of combining the Darboux transformation with the reciprocal transformation.

Soliton interactions in the sharp-line Maxwell-Bloch system

Schedule: July 8 9:30-10:00 Room 640

Sitai Li

Xiamen University, Peoples Rep of China

Abstract:

We consider N -soliton solutions of the sharp-line Maxwell-Bloch system that may contain multiple degenerate soliton groups (DSGs). A DSG is a localized coherent nonlinear traveling-wave structure, consisting of inseparable solitons with identical velocities. Thus, DSGs are generalizations of single solitons (considered as 1-DSGs), and constitute fundamental building blocks for the solutions of many integrable systems. We provide explicit formulae for an N -DSG and its center, and calculate the long-time asymptotics for such solutions. We also briefly discuss high-order soliton solutions, which can be regarded as generalizations of the N -soliton solutions.

Dispersive regularization of Talanov focusing in the AKNS hierarchy

Schedule: July 8 8:00-8:30 Room 640

Peter D Miller

University of Michigan, USA

Abstract:

It was shown in the 1960s by Talanov that there exist solutions of the dispersionless focusing nonlinear Schrödinger equation with a parabolic amplitude profile that collapse and blow up in finite time. Accounting for the effect of small dispersion, Suleimanov conjectured in 2017 that the corresponding solution of the nonlinear Schrödinger equation should be regularized with a particular wave profile that was later characterized as a certain infinite-order limit of fundamental rogue waves. We describe a recent proof of a version of Suleimanov's conjecture and explain how it generalizes to the full AKNS hierarchy.

Stability of Elliptic Function Solutions and Dynamics of Elliptic-Localized Waves

Schedule: July 8 14:30-15:00 Room 640

Xuan Sun

Donghua University, Peoples Rep of China

Co-Author(s): Liming Ling

Abstract:

This report investigates the stability of elliptic function solutions and elliptic localized wave solutions to integrable nonlinear soliton equations. We construct elliptic localized wave solutions in rational form and establish a correspondence between elliptic rogue waves and modulational instability. Furthermore, we analyze the spectral and orbital stability of the elliptic function solutions.

The Kadomtsev-Petviashvili reduction method and its applications to the (coupled) Sasa-Satsuma equation

Schedule: July 8 13:30-14:00 Room 640

Chengfa Wu

Shenzhen University, Peoples Rep of China

Co-Author(s): Feng Bao-Feng, Shi Changyan, and Zhang Guangxiong.

Abstract:

In this talk, we will provide an overview of the Kadomtsev-Petviashvili (KP) reduction method, a powerful technique for deriving exact solutions to nonlinear partial differential equations. In particular, we will focus on the Sasa-Satsuma equation, a higher-order nonlinear Schrödinger-type equation that plays a crucial role in nonlinear optics and fluid dynamics. Using the KP reduction method, we construct explicit rogue wave solutions. This talk is based on joint work with Feng Bao-Feng, Shi Changyan, and Zhang Guangxiong.

Equivalence between Wronskian- and Grammian-type solutions and asymptotic analysis of N-soliton solutions for the Gerdjikov-Ivanov equation

Schedule: July 8 15:00-15:30 Room 640

Tao Xu

China University of Petroleum-Beijing, Peoples Rep of China

Co-Author(s): Yuxin Yang, Chuanxin Xu, Min Li

Abstract:

For the Gerdjikov-Ivanov (GI) equation, we rigorously prove the equivalence between the Wronskian- and Grammian-type solutions derived from the elementary and binary Darboux transformations, respectively. The proof is finished by making complete Wronskian expansions and establishing the relations between the corresponding numerators and denominators of two determinant solutions. Meanwhile, some determinant identities are obtained as a byproduct upon comparing the coefficients of the same terms in the expansions. Furthermore, we conduct asymptotic analysis for N-soliton solutions on the zero and plane-wave backgrounds. Explicit asymptotic expressions are obtained as t goes to infinity, yielding the physical information of interacting solitons, such as amplitudes, velocities, and phase shifts before and after collisions. In particular, we derive the general parametric conditions for synchronous N-soliton collisions at arbitrary space-time points on both backgrounds. This scenario may be useful for understanding complex behavior for a large number of solitons, e.g., the generation of rogue waves via soliton collisions.

Modeling and Mathematical Analysis of a Higher-Order CH-KP Model for Shallow Water Waves

Schedule: July 8 14:00-14:30 Room 640

Shouming Zhou

Chongqing normal University, Peoples Rep of China

Abstract:

This study employs a systematic asymptotic expansion method to derive a two-dimensional nonlocal model for shallow water wave propagation from the full hydrodynamic governing equations. The local well-posedness of the resulting higher-order two-dimensional extension of the Camassa-Holm type equation is established in a suitably constructed Sobolev-type space, and the blow-up criterion as well as peaked solitary-wave solutions are also considered.

Special Session 52 : Differential Equations and Dynamical Systems in Mathematical Biology

Organizer(s): Peter Hinow , Jozsef Farkas , Peter Rashkov

Introduction: The use of mathematical models to shed light on phenomena in the life sciences is a well-established practice, having been used for over a century now. A very vivid experience of this kind was the outbreak of the Covid19 pandemic, when even lay people were learning about the meaning of R_0 and many policymakers all over the world were relying on predictions of mathematical models. By their very nature, differential equations, dynamical systems and stochastic processes are key tools, as they can be investigated with analytical and numerical methods. Our special session will bring together junior and senior scientists from a diverse set of backgrounds to present and discuss recent trends and progress in their specific fields of interest. We plan to focus on fields such as cancer modeling, infectious diseases, computational neuroscience and ecology.

Period Homeostasis Near Hopf Bifurcation

Schedule: July 10 17:00-17:30 Room 812

Janet Best

The Ohio State University, USA

Co-Author(s): Steve Manns, Martin Golubitsky

Abstract:

Homeostasis is a biological phenomenon in which a function of the state of the system remains approximately constant as an input parameter varies. Recently, Golubitsky and collaborators have developed a mathematical theory of homeostasis based on methods from singularity theory. In this theory, the state is a steady state, and the function is often a coordinate of the steady state. The weaker requirement that a function of the state remain approximately constant is replaced by the requirement that the derivative of the function with respect to the input parameter vanishes at an isolated point. This notion of a zero derivative has the name (steady-state) infinitesimal homeostasis, by which we mean that we are focusing on a function of a system steady state. Homeostasis can also apply to many oscillatory biological processes. For example, the period of circadian rhythms remains approximately constant as parameters such as ambient temperature and gene expression levels vary. In this talk, I will present results on infinitesimal homeostasis for periodic phenomena in models that undergo nondegenerate Hopf bifurcation. Our main result in this setup is that singularity theory can be used to find period homeostasis. This result is illustrated using numerical simulations of a simple model of the mammalian circadian clock. Our theoretical results are based on having two parameters (a bifurcation parameter and an input parameter) and the S^1 symmetry of Hopf normal form.

Invasion, replacement and coexistence in ecological models

Schedule: July 10 18:00-18:30 Room 812

CAMERON BROWNE

University of Louisiana at Lafayette, USA

Abstract:

How invasions of ecosystems by novel species or variants unfold and their ripple effects on the community are central questions in ecology and evolution. In this work, we explore how an invader can replace a resident species in different ecological networks and/or models. Through the lens of modern coexistence theory and invasion rates, we analyze feasibility and stability of invaded multi-species equilibria, along with persistence of associated species. As invader growth rate increases, there is either generically a gradual transition from invasion to replacement or non-generically an abrupt bifurcation where invasion and replacement occur simultaneously. We develop algebraic methods for predicting which species are replaced in different scenarios, particularly in the non-generic case which includes dynamics of multi-species Lotka-Volterra, consumer-resource and predator-prey networks. In these examples, we also study how the presence and functional form of trade-offs or fitness landscapes can lead to distinct convergent ecosystem structures.

Agent-based and continuum models for spatial dynamics of infection by oncolytic viruses

Schedule: July 10 9:30-10:00 Room 812

Marcello Delitala

Politecnico di Torino, Italy

Co-Author(s): David Morselli and Federico Frascoli

Abstract:

We present a stochastic agent-based model for the spatial dynamics of infection by oncolytic viruses in solid tumours. The model describes the interactions between uninfected and infected tumour cells and considers two alternative movement mechanisms, namely undirected random motion and pressure-driven displacement. For both cases, we obtain the corresponding continuum equations and carry out a systematic comparison between the individual-based and PDE descriptions in one and two space dimensions. We also study the associated one-dimensional travelling waves. In the case of undirected motion, the agreement between agent-based simulations and the numerical and analytical results for the continuum model is good. For pressure-driven motion, instead, marked discrepancies emerge: over a wide parameter range, infection remains confined to the tumour core, even though the continuum model predicts travelling infection waves. These results highlight the significant impact of spatial constraints in the tumour microenvironment on virotherapy, as well as the central role of stochastic effects. The same modelling framework also provides a natural basis for extensions including explicit viral particles, making it possible to assess when reduced quasi-steady descriptions are adequate and when viral kinetics significantly affect front propagation and transient behaviour. This talk is based on results published in *Bulletin of Mathematical Biology* 85:92 (2023) and 88:66 (2026).

A two-patch SEIR model with prevalence-dependent behavioural response and mobility for Ebola dynamics

Schedule: July 10 10:30-11:00 Room 812

Attila Denes

Bolyai Institute, University of Szeged, Hungary

Co-Author(s): Abba B. Gumel

Abstract:

We develop a two-patch SEIR model for Ebola transmission that incorporates human behaviour and mobility. We consider two patches representing urban and rural environments, and in each patch, the population is further divided into two groups based on their willingness to adhere to intervention measures. Both adherence and travel is influenced by disease prevalence. Unlike traditional approaches assuming permanent migration, we adopt a more realistic framework where individuals retain residency in their home region while spending time in the other region. We analyse key model properties, including the control reproduction number, and show that the disease dies out when this threshold is below one. Parameters are estimated by fitting a simplified version of the model -- excluding behavioural heterogeneity and travel -- to epidemiological data from the 2018--2020 outbreak in the Democratic Republic of Congo. We then conduct scenario-based analyses to investigate the impact of behavioural responses, misinformation, regional resource allocation, and travel duration on epidemic dynamics. The results highlight the importance of adaptive behaviour and mobility in shaping disease spread and control strategies.

Evolution into chaos -- implications of the trade-off between transmissibility and immune evasion

Schedule: July 10 15:00-15:30 Room 812

Abel Garab

University of Szeged, Hungary

Co-Author(s): Golsa Sayyar and Gergely Röst

Abstract:

Predicting viral evolution presents a significant challenge and is a critical public health priority. We develop a novel model that selects for a new strain with the highest invasion fitness, assuming a trade-off between immune evasion and transmissibility. In case the trade-off function is linear, we can describe the evolutionary patterns following the emergence of subsequent strains by a non-linear difference equation. We provide sufficient criteria for when evolution converges, and successive strains exhibit similar transmissibility. We also identify scenarios characterized by a two-periodic pattern in upcoming strains, indicating a situation where a highly transmissible but not immune-evasive strain is replaced by a less transmissible but highly immune-evasive strain, and vice versa, creating a cyclic pattern. Finally, we show that under certain conditions, viral evolution becomes chaotic and thus future transmissibility rates become unpredictable in the long run.

Modeling the impact of antigenic distance and immune imprinting of sequential viral infections on disease severity

Schedule: July 10 17:30-18:00 Room 812

Hayriye Gulbudak

University of Louisiana at Lafayette, USA

Co-Author(s): Nazia Afrin, Cameron Browne, Anna Jolles, Brianna Beechler

Abstract:

For many diseases, at various times after the primary infection, sequential infection can occur with diverse viral strains. Here we introduce a simple model that presents a balance between two distinct adaptive immune responses: cross-reactive responses derived from preexistent antibodies and specific antibodies generated during secondary infection. Our analytical and numerical results suggest that cross-reactive antibodies dominate the adaptive immune response when viral strains are similar, even if the initial cross-reactive response is sufficiently small; thus the waning period does not affect the ratio of adaptive to cross-reactive antibodies significantly. However, the waning period and antigenic similarity both matter to viral production and host damage, with greatest production and most damage occurring when the initial cross-reactive response is large and viruses are dissimilar. Moreover, adaptive immunity lowers disease severity, while a higher pathogen growth rate increases it, showing that disease outcome depends on both immune responses and pathogen traits. In addition, sequential infections with a circulating strain that is antigenically very similar to a previous infection may limit the hosts ability to mount a diverse portfolio of immune responses. Therefore, understanding how immune imprinting shapes the overall host immune response can be critical for effective protection during an epidemic.

Energy-Driven Organization and Positivity in a Beetle-Inspired Droplet System with Non-Newtonian Fluids

Schedule: July 10 9:00-9:30 Room 812

Thomas Hagen

The University of Memphis, USA

Abstract:

Motivated by a surface based defense strategy of the leaf beetle *Hemisphaerota cyanea*, we analyze a biomathematical model for surface tension driven fluid transport in networks of interconnected droplets. Curvature induced pressure differences generate volume exchange through narrow channels, producing competitive growth and extinction dynamics within the droplet ensemble. The model takes the form of a graph based system of ordinary differential equations and incorporates power law rheology to capture non Newtonian biological fluids. In the shear thickening regime, solution nonuniqueness challenges the interpretation of biologically meaningful behavior. We establish that positivity of droplet volumes is preserved, ensuring physical relevance despite the lack of uniqueness. Moreover, the long term dynamics are shown to be simple and robust: all trajectories converge to equilibria. An energy functional linked to surface area provides a Lyapunov structure that orders steady states and clarifies long term outcome selection.

Modeling Combination Therapy to Overcome NUPR1-mediated Docetaxel Resistance in Prostate and Pancreatic Cancer

Schedule: July 10 8:30-9:00 Room 812

Harsh Jain

University of Minnesota Duluth, USA

Abstract:

Resistance to the taxane docetaxel is a major obstacle in the treatment of solid tumors, particularly prostate and pancreatic cancer. The stress-response protein NUPR1 has been identified as an important molecular driver of docetaxel resistance, suggesting that pharmacologic inhibition of NUPR1 may restore treatment sensitivity. While the early NUPR1 inhibitor ZZW-115 demonstrated promising anti-tumor activity, concerns about cardiotoxicity motivated the development of next-generation NUPR1-targeting compounds such as AJO14 and related derivatives. In this work we develop mechanistic mathematical models to investigate tumor response to combined docetaxel and NUPR1-targeted therapy. The models are informed by preclinical data, including in vitro prostate cancer cell-line experiments and in vivo pancreatic cancer xenografts. Using these calibrated models, we quantify treatment effects, explore potential synergy between therapies, and extend the analysis to heterogeneous virtual populations to examine how variability in tumor growth and drug response influences outcomes. This framework provides a quantitative approach for evaluating strategies to overcome docetaxel resistance and for guiding the development of NUPR1-targeted combination therapies.

Obesity Epidemic: Impact of Genetics, Environment and Social Behavior

Schedule: July 10 11:00-11:30 Room 812

Yun Kang

Arizona State University, USA

Abstract:

This study develops a mathematical model to examine obesity dynamics within a population, incorporating genetics, social, behavioral, and environmental factors. The model segments the population into susceptible, obese, and recovered but at-risk classes, using a system of nonlinear ordinary differential equations to describe transitions between them. Key mechanisms include social influence, diet, physical activity, and public health interventions. Theoretical results identify equilibrium states and the conditions under which obesity prevalence persists or declines. Bifurcation analysis illustrates how intervention strategies-such as promoting healthy lifestyles or reducing social reinforcement of unhealthy behaviors-affect long-term outcomes. The findings suggest that both social norms and individual behavior strongly shape obesity dynamics, and that sustained, multifaceted interventions are required to reduce prevalence. This framework offers a quantitative tool for policymakers to design and evaluate targeted obesity prevention programs.

Is maximum tolerated dose (MTD) chemotherapy scheduling optimal for glioblastoma multiforme?

Schedule: July 10 12:00-12:30 Room 812

Chiu-Yen Kao

Claremont McKenna College, USA

Co-Author(s): Chiu-Yen Kao, Seyyed Abbas Mohammadi, Mohsen Yousefnezhad

Abstract:

In this study, we investigate a control problem involving a reaction-diffusion partial differential equation (PDE). Specifically, the focus is on optimizing the chemotherapy scheduling for brain tumor treatment to minimize the remaining tumor cells post-chemotherapy. Our findings establish that a bang-bang increasing function is the unique solution, affirming the MTD scheduling as the optimal chemotherapy profile. Several numerical experiments on a real brain image with parameters from clinics are conducted for tumors located in the frontal lobe, temporal lobe, or occipital lobe. They confirm our theoretical results and suggest a correlation between the proliferation rate of the tumor and the effectiveness of the optimal treatment.

How does asthma prevent optic glioma?

Schedule: July 10 13:30-14:00 Room 812

Yangjin Kim

Konkuk University/Brown University, Korea

Co-Author(s): Donggu Lee, Sean Lawler

Abstract:

Optic glioma, a slow-growing tumor, is associated with Neurofibromatosis type 1 (NF1) mutations and increased midkine (MDK) production. A connection between asthma and optic glioma has previously been observed, but the mechanisms are unclear. To elucidate the role of asthma in the regulation of glioma formation, we investigated the role of T cells and the subsequent pathways in the regulation of microglia, a key player in the glioma tumor microenvironment (TME). While asthma is often linked to chronic inflammation, our mathematical analysis and experimental evidence suggest that inflammation can play a key role in suppressing the proliferation of optic glioma cells via immune reprogramming of T cells and the delicate control of signaling networks in microglia. Our mathematical model unveils the complex interactions between tumor and immune cells in optic glioma. Our results indicate that asthma-induced T cell reprogramming inhibits tumor growth by promoting the release of decorin and a subsequent suppression of CCR8 and the intercellular binding kinetics in microglia, followed by blocking of CCL5 production in TME via suppression of NFkB. We developed anti-cancer strategies by leveraging this asthma-induced immune regulation. We also developed a multi-scale model that take into account spatial dynamics of immune cells and intracellular signaling in multi-scale framework in space and time.

Analysis of a two-phase model describing the growth of solid tumors

Schedule: July 10 11:30-12:00 Room 812

Anca Matic

University of Regensburg, Germany

Co-Author(s): Joachim Escher

Abstract:

In this talk we consider a two-phase model describing the growth of avascular solid tumors when taking into account the effects of cell-to-cell adhesion and taxis due to nutrient. The tumor is surrounded by healthy tissue which is the source of nutrient for tumor cells. In a three-dimensional context, we prove that the mathematical formulation corresponds to a well-posed problem, and find radially symmetric steady-state solutions of the problem. They appear in the regime where the rate of cell apoptosis to cell proliferation is less than the far field nutrient concentration. Furthermore, we study the stability properties of those radially symmetric equilibria and find, depending on the biophysical parameters involved in the problem, both stable and unstable regimes for tumor growth. (Joint work with Joachim Escher, Hanover)

Travelling Waves in a Mathematical Model for Oncolytic Virotherapy

Schedule: July 10 16:30-17:00 Room 812

Negar Mohammadnejad

University of Alberta, Canada

Co-Author(s): Thomas Hillen

Abstract:

Oncolytic virotherapy (OVT) is a promising cancer treatment strategy in which engineered viruses selectively infect and destroy tumor cells. Motivated by the biological processes governing viral spread and tumor invasion, we study a non-cooperative reaction-diffusion model describing the spatial propagation of oncolytic viruses within tumor tissue. In this work, we establish the existence of positive travelling-wave solutions and identify a minimal wave speed $\bar{c}$ such that travelling waves exist for all speeds $c \geq \bar{c}$. The results provide a rigorous foundation for understanding the spatial dynamics of OVT and reveal parameter regimes where wave existence remains unresolved, pointing to new mathematical challenges in modeling viral spread in complex tumor environments.

The transition to parenthood in a romantic relationship: A modeling approach

Schedule: July 10 14:00-14:30 Room 812

Matilde Polizzi

Politecnico di Milano, Italy

Co-Author(s): Alessandra Gragnani, Fabio Dercole

Abstract:

The transition to parenthood is a major life event that can profoundly reshape couple emotional dynamics. Starting from a mathematical model of love dynamics in a couple, this work introduces two additional parameters representing caregiving load and the allocation of childcare responsibilities between partners. The extended system is used to investigate how the birth of a child modifies couple regimes and average emotional involvement between the partners. The analysis is carried out for different attachment configurations. For secure-secure couples, increasing caregiving load lowers equilibrium involvement, while the distribution of responsibilities produces trade-offs between equity, total involvement, and robustness. For insecure-secure couples, results are similar but increasing caregiving load may increase the equilibrium involvement of the insecure partner. Moreover, when one partner's reactions are self-biased by their own involvement, caregiving load can either induce or suppress oscillatory regimes. Finally, when caregiving load is periodic, the interaction between endogenous and exogenous oscillations may generate quasi-periodic or chaotic regimes. Overall, the results show that parenthood acts as a perturbation of love dynamics, shaping relational outcomes according to attachment style, caregiving load, and the distribution of parental responsibilities.

Self-regulation and resource dependent growth rates: a size-structured predator-prey mode

Schedule: July 10 8:00-8:30 Room 812

Andrea Pugliese

University of Trento, Italy

Co-Author(s): Simone De Reggi, Shangjiang Guo, Mimmo Iannelli and Xuan Tian

Abstract:

The dynamical behaviour of a size-structured predator-prey model with nonlinear growth rates is studied. In the model prey growth rate the model is described by the following system of quasi-linear equations where $u(t, s)$ and $v(t, s)$, for $t \geq 0$ and $s \in (0, 1)$, denote the maximal size:

$$\begin{cases} \frac{\partial}{\partial t} u(t, s) + \frac{\partial}{\partial s} [g_1(U(t), s) u(t, s)] &= -[d_1(s) + (Hv(t, \cdot))(s)] u(t, s), \\ \frac{\partial}{\partial t} v(t, s) + \frac{\partial}{\partial s} [g_2((Ku(t, \cdot))(s), s) v(t, s)] &= -d_2(s) v(t, s) \end{cases}$$

where $H, K: L^1((0, 1), \mathbf{R}) \rightarrow L^1((0, 1), \mathbf{R})$ are

$$(H\phi)(s) = \int_0^1 k(z, s) \phi(z) dz, \quad (K\phi)(s) = \int_0^1 k(s, z) \phi(z) dz$$

for $k \in L^1((0, 1)^2, \mathbf{R})$ (in other words, H is the adjoint of K), and

$$U(t) = \int_0^1 u(t, s) ds,$$

Existence and uniqueness of solutions are proved under weak conditions. A threshold is established for the stability of the predator-free of the one studied by Farkas and Hagen (2007); in this case it is shown that the positive equilibrium may undergo Hopf bifurcation, a new pseudospectral collocation methods.

A new framework for Generalized L

Schedule: July 10 14:30-15:00 Room 812

Polly Y. Yu

University of Illinois Urbana-Champaign, USA

Co-Author(s): Gheorghe Craciun, Diego Rojas La Luz

Abstract:

Generalized Lotka-Volterra (GLV) systems, as models of ecological communities, can display diverse dynamics, ranging from global stability, to periodic orbits, and even chaos. We propose a framework of studying GLV systems by borrowing ideas from reaction network theory, specifically the notions of detailed-balanced and complex-balanced. We associate any GLV system to a directed graph embedded in $\mathbb{R}^n$, and prove theorems of the form: If the graph has property P , then the associated GLV system has dynamical property X . For example, if the embedded graph is strongly connected, then the GLV system has a globally stable coexistence equilibrium (within each invariance manifold). The stability is guaranteed by a different Lyapunov function than the Volterra Lyapunov function. Other dynamical properties we can infer include persistence, and ruling out limit cycles.

Special Session 54 : Trends in Nonlinear Analysis

Organizer(s): Olimpio Miyagaki , GUSTAVO MADEIRA , ALANNIO NOBREGA

Introduction: Partial Differential Equations (PDEs) have been a cornerstone of mathematical research for over three centuries, renowned for their profound impact on modeling complex phenomena across diverse scientific disciplines, including Physics, Economics, and Biology. On the global stage, Nonlinear Analysis has emerged as a fundamental pillar in both applied and theoretical mathematics, driving significant advancements in our understanding of nonlinear systems. Leading research centers worldwide continue to foster interdisciplinary collaborations, accelerating innovation and the development of cutting-edge methodologies to tackle intricate mathematical challenges. Bringing together experts in Nonlinear Analysis and PDEs is not only vital for pushing the frontiers of theoretical and applied mathematics but also for strengthening international cooperation and cultivating the next generation of researchers. In an increasingly interconnected world that depends on sophisticated scientific solutions, such initiatives are crucial to sustaining progress, expanding knowledge, and enhancing the real-world applicability of mathematical discoveries.

Liouville properties for differential inequalities with (p, q) Laplacian operator

Schedule: July 6 13:30-14:00 Room 430

Mousomi Bhakta

Indian Institute of Science Education and Research Pune (IISER Pune), India

Co-Author(s): Anup Biswas, Roberta Filippucci

Abstract:

We will discuss several Liouville-type theorems for nonnegative solutions associated with a class of nonhomogeneous quasilinear inequalities, namely
$$\begin{cases} -\Delta_p u - \Delta_q u \geq u^{s-1} \\ \text{in } \Omega, \end{cases}$$
 where $p > q > 1$, $s > 1$ and Ω is any exterior domain of $\mathbb{R}^N$ and
$$\begin{cases} -\Delta_p u - \Delta_q u \geq u^s |\nabla u|^m \\ \text{in } \mathbb{R}^N, \end{cases}$$
 where $p > q > 1$, $N > q$ and $s, m \geq 0$.

Multiplicity of critical orbits to nonlinear, strongly indefinite functionals with sign-changing nonlinear part

Schedule: July 6 14:00-14:30 Room 430

Bartosz Bieganowski

University of Warsaw, Poland

Abstract:

We will present an abstract critical point theory that allows to study the multiplicity of critical points of strongly indefinite functionals with sign-changing nonlinear part. We are going to apply it to nonlinear Schrödinger-type equations that appear e.g. in nonlinear optics. This is a joint work with Federico Bernini and Daniel Strzelecki.

Nonresonance for problems involving (p, q) -Laplacian equations with nonlinear perturbations

Schedule: July 6 14:30-15:00 Room 430

Nsoki Mavinga

Swarthmore College, USA

Co-Author(s): Emer Lopera, Diana Sanchez

Abstract:

We consider (p, q) -Laplacian problems that include nonlinear perturbation terms in both the differential equations and the boundary. We use variational methods and critical point theory to prove the existence of weak solutions for the nonlinear problem when the nonlinearities involved remain asymptotically below the infimum of the set of eigenvalues of the (p, q) -Laplacian problem with weights and a spectral parameter present in both the differential equation and the boundary. We also establish an existence result for the nonlinear problem when the nonlinearities involved remain asymptotically below the first Steklov-Neumann eigenvalue-line, which is a line connecting the first Steklov and first Neumann eigenvalues for q -Laplacian problems with weights and a spectral parameter present either in the differential equation or on the boundary.

ON COMPACT EMBEDDINGS INTO L^p AND FRACTIONAL SPACES

Schedule: July 6 18:00-18:30 Room 430

Olimpio Miyagaki

UFSCAR, Brazil

Co-Author(s): H.P. BUENO, A.H.S. MEDEIROS, O.H. MIYAGAKI, AND G.A. PEREIRA

Abstract:

The study of the fractional Laplacian operator $(-\Delta)^s$ in $\mathbb{R}^N$ with Dirichlet boundary conditions gained enormous momentum through its identification with a Neumann operator in $\mathbb{R}^N \times (0, \infty) = \mathbb{R}_+^{N+1}$, a method mainly introduced by Caffarelli and Silvestre. Since then, several other operators have been studied using this method. In general, a crucial question is attached to this method: is the embedding (in the trace sense) on the ground space $L^q(\mathbb{R}^N)$ compact? This question is very important when dealing with problems of existence of solutions. This paper aims to answer this question for some operators. Passing to an abstract setting, let X, Y be Hilbert spaces and $\mathcal{A}: X \rightarrow X'$ a continuous and symmetric operator. We suppose that X is dense in Y and that the embedding $X \subset Y$ is compact. In this paper we show some consequences of this setting for the study of the fractional operator attached to $\mathcal{A}$ in the extension setting $\Omega \times (0, \infty)$ or $\mathbb{R}_+^{N+1}$. Being more specific, we will give some examples where the embedding of the extension domain into $L^2(\Omega)$ is compact, even in the case $\Omega = \mathbb{R}^N$.

Quasilinear elliptic problems with nonlinear perturbations involving critical Sobolev exponents

Schedule: July 6 17:30-18:00 Room 430

M N Nkashama

University of Alabama at Birmingham, USA

Co-Author(s): N. Mavinga

Abstract:

We will present some recent results on the existence of weak minimal and maximal solutions between an ordered pair of sub- and super-solutions for nonlinear (Carathéodory) perturbations of quasilinear elliptic equations (including the p -Laplacian). No monotonicity conditions are imposed on the nonlinear perturbations. Unlike previous results in this setting, we allow the growth of the nonlinear perturbations to go all the way to the critical Sobolev exponents in the appropriate Lebesgue spaces. The approach makes careful use of topological degree theory arguments for demicontinuous operators of class (S_+) with some ingredients from pseudomonotone operators, Zorn's lemma and a Kato inequality with appropriate estimates.

Travelling waves for Maxwell's equations in nonlinear symmetric media

Schedule: July 6 17:00-17:30 Room 430

Jacopo Schino

University of Warsaw, Poland

Co-Author(s): Jarosław Mederski

Abstract:

We consider a semilinear curl-curl problem arising from Maxwell's equations in a cylindrically symmetric medium. Exploiting a variant of the fountain theorem, we obtain an unbounded sequence of travelling-wave solutions that consist of transverse magnetic field modes, which makes them different from those obtained in the seminal work by McLeod, Stuart, and Troy.

The non-local eigenvalue problems for the p -Laplacian

Schedule: July 6 16:30-17:00 Room 430

Mieko Tanaka

Tokyo University of Science, Japan

Abstract:

I'll talk about the non-local eigenvalue problems for the p -Laplacian, which derived from the Sobolev-Poincaré inequality. In particular, I'd like to focus on the least eigenvalue among those having sign-changing eigenfunctions.

Existence and multiplicity of solutions to the mean-field games model with mixed interactions

Schedule: July 6 15:00-15:30 Room 430

Yuanze Wu

School of Mathematics, Yunnan Normal University, Peoples Rep of China

Co-Author(s): Xinfu Li, Xiangqing Liu, Juncheng Wei

Abstract:

I will report our recent results on the stationary version of the Mean-Field Games (MFG) models. By developing the minimization method on the Pohozaev manifold, we prove the existence and multiplicity of radial solutions of the Mean-Field Games (MFG) models with general p -homogeneous hamiltonians and mixed interactions under more general conditions.

Special Session 55 : Nonlocal effects in diffusion equations

Organizer(s): Xueli Bai , Fang Li , Xuefeng Wang

Introduction: Nonlocal effects are ubiquitous in nature. In particular, in reaction-diffusion equations, the emergence of nonlocal effects often brings about some new mathematical phenomena or leads to new mathematical difficulties. In this session, we hope to exchange ideas on the studies of qualitative properties of solutions to reaction-diffusion equations with nonlocal effects, and hope to deepen our understanding of the mathematical theories related to nonlocal effects in reaction-diffusion equations through discussion and promote new cooperation.

Some Progress on Single Species Models with Nonlocal Dispersal Strategies in Heterogeneous Environments

Schedule: July 6 13:30-14:00 Room 311

Xueli Bai

Northwestern Polytechnical University, Peoples Rep of China

Co-Author(s): Fang Li, Jiale Shi

Abstract:

In this talk, we consider a single species model with nonlocal dispersal strategy and discuss how the dispersal rate and the distribution of resources affect the total population and survival chances by summarizing some previous results and demonstrate some relevant progress. The first topic is about the monotonicity of total population upon dispersal rate. For the nonlocal model, we prove a new result, which reveals essential difference between local and nonlocal models for certain distribution of resources. Secondly, we discuss optimal spatial arrangement for survival chances and total populations. The results for both local and nonlocal models demonstrate that the concentration of resources is beneficial for species.

Nonlocal Effects in Deterministic and Stochastic Pseudo-Parabolic Equations

Schedule: July 6 14:00-14:30 Room 311

Yang Cao

Dalian University of Technology, Peoples Rep of China

Co-Author(s): Haomeng Chen, Chunhua Jin, Jingxue Yin

Abstract:

This report examines nonlocal effects in pseudo-parabolic equations across deterministic and stochastic settings. In the deterministic case, When $\tau/D \leq 1$, the pseudo-parabolic term acts as a structure-preserving regularization, and the traveling waves retain the monotonicity of classical Fisher-KPP fronts; when $\tau/D > 1$, it actively induces oscillations in the wave profile near the equilibrium $u = 1$. This predicts the saturation overshoot observed in porous media but absent in classical diffusion. In the stochastic counterpart, the nonlocal effect results in a bounded operator spectrum, which restricts the dissipation rate of high-frequency modes to a finite level and forces trajectory estimators to depend on long-time observations, while sustaining noise responses that make MLE asymptotic variance dimension-independent. Both manifestations reveal how nonlocal structure fundamentally reshapes wave dynamics and statistical estimability.

A study on the regularity of mixed local-nonlocal problems with measure data

Schedule: July 6 14:30-15:00 Room 311

Mengyao Ding

Harbin institute of Technology, Peoples Rep of China

Co-Author(s): YingLi, ChaoZhang

Abstract:

We investigate the existence, uniqueness, and regularity of solutions in the framework of fractional Sobolev spaces for mixed local-nonlocal problems with measure data. By combining techniques from the theory of linear elliptic equations with nonlocal operators and classical potential theory, we derive some regularity estimates for the equation.

Self-similar Singular Solutions for the Critical Keller-Segel Model with p -Laplacian Diffusion

Schedule: July 6 15:00-15:30 Room 311

Chunhua Jin

South China Normal University, Peoples Rep of China

Abstract:

In this talk, we focus on the critical dynamics of the Keller-Segel model with p -Laplacian diffusion. We first establish a sharp threshold that distinguishes globally bounded solutions from finite-time blow-up. In the critical case, we rigorously construct backward self-similar blow-up solutions with compact support and radial monotonicity. These solutions exhibit concentration into a Dirac δ -singularity at the blow-up time as their support shrinks to the origin. Additionally, we explore forward self-similar singular solutions, further characterizing their initial singularity.

Existence and nonexistence of stable patterns in semilinear nonlocal diffusion equations

Schedule: July 6 15:30-16:00 Room 311

Fang Li

Sun Yat-sen University, Peoples Rep of China

Co-Author(s): Xueli Bai, Xuefeng Wang

Abstract:

In this talk, we consider the dynamics of semilinear nonlocal diffusion equations on bounded domains with no-flux boundary conditions, specifically focusing on the existence and stability of non-constant steady states, referred to as patterns. According to the results of Casten, Holland, and Matano regarding semilinear local diffusion equations, we know that stable patterns do not exist in convex domains, while they do emerge in dumbbell-shaped geometries, particularly when the kinetic term is bistable. We extend these findings to nonlocal diffusion analogs, demonstrating the absence of stable smooth patterns in both one-dimensional intervals and multi-dimensional balls. In addition, we construct discontinuous, asymptotically stable patterns when the kinetic term is bistable. Our results reveal a significant principle: large nonlocal diffusion tends to destabilize patterns, whereas weak nonlocal diffusion stabilizes them, especially in cases with bistable kinetic terms. Importantly, the geometry of the domain appears to play a less critical role in this process of stabilization.

Cauchy problem of the parabolic-elliptic density suppressed motility model with logistic source

Schedule: July 6 16:30-17:00 Room 311

Jing Li

Minzu University of China, Peoples Rep of China

Co-Author(s): Wang Zhi-an, Xu Wenbing

Abstract:

To understand the "self-trapping" mechanism inducing spatio-temporal pattern formations observed in the experiment of for bacterial motion, the density-suppressed motility model was proposed. The purpose of this paper is to consider the Cauchy problem with the motility function $\gamma(v) = \frac{1}{(1+v)^m}$ we obtain that the condition $0 \leq m \leq \frac{2}{(N-2)_+}$ can warrant the global boundedness of solutions, based on which the asymptotic spreading behavior for solutions which are observed for genuine patterns in the experiment is verified.

On principal eigenvalues for elliptic operators with divergence-free flow

Schedule: July 6 17:30-18:00 Room 311

Shuang Liu

Beijing Institute of Technology, Peoples Rep of China

Co-Author(s): Yuan Lou

Abstract:

In this talk, we will discuss some progress on principal eigenvalues of second order elliptic operators with the divergence-free flow. Some monotonicity and asymptotic behaviors of principal eigenvalues, with respect to diffusion rate and flow amplitude, are established. These local asymptotic analysis can help us find some global information on the principal eigenvalue, which enables us to better understand qualitative properties of the principal eigenvalues. This is a joint work with Professor Yuan Lou.

Precise propagation dynamics of the nonlocal KPP free boundary problem with non-symmetric kernels

Schedule: July 6 18:00-18:30 Room 311

Wenjie ni

University of New England, Australia

Abstract:

This talk presents our recent joint work with Professor Yihong Du and Professor Xiangdong Fang on the asymptotic limit of the principal eigenvalue of asymmetric nonlocal diffusion operators and its implications for propagation dynamics in Fisher KPP type equations. We first establish an explicit formula for the asymptotic limit of the principal eigenvalue of a nonlocal diffusion operator with drift, revealing how the asymmetry of the dispersal kernel affects the spectral structure. Building on this result, we analyze the long-term behavior of nonlocal KPP equations using a new eigenvalue-based approach that avoids the reliance on traveling waves.

Multiscale Nonlocal Modeling of Phenotypic Plasticity and Drug Resistance in Glioblastoma

Schedule: July 7 8:00-8:30 Room 311

Xiaoqiang Sun

Sun Yat-sen University, Peoples Rep of China

Co-Author(s): Ming Yan, Xiaoqiang Sun

Abstract:

Glioblastoma (GBM) progression is driven by the dynamic interplay between tumor cells, which transition between proneural (PN) and mesenchymal (MES) states, and tumor-associated macrophages (TAMs), which shift between M1 and M2 phenotypes. In this study, we developed a multiscale spatiotemporal model based on nonlocal reaction-diffusion equations to investigate the intrinsic mechanisms of GBM phenotypic transitions during both natural progression and drug treatment. The model integrates continuous tumor and TAM phenotypic shifts and their interplay via microenvironment-mediated signaling feedback loops. Through rigorous mathematical analysis, we established the well-posedness of the model and constructed an efficient numerical scheme for its solution. The model demonstrates excellent agreement with experimental observations across multiple validation metrics, confirming its biological plausibility and predictive capability. Using global sensitivity analysis and parameter stability analysis, we systematically identified and quantitatively characterized key parameters regulating tumor growth dynamics and treatment response. Finally, we evaluated the efficacy of combination therapy regimens and proposed strategic approaches for optimizing GBM treatment. Our study establishes a novel nonlocal modeling framework for investigating phenotypic plasticity in tumor and immune cells and their crosstalk, providing valuable insights for optimizing combination therapies in cancer treatment.

Principal Eigenvalue of Second Order Elliptic Operators

Schedule: July 7 8:30-9:00 Room 311

Xin Xu

South China Normal University, Peoples Rep of China

Co-Author(s): Xueli Bai, Rui Peng, Zhi-an Wang, Kexin Zhang, Maolin Zhou

Abstract:

In this talk, we would like to report our recent work on the convergence of the principal eigenvalue of the elliptic operator
$$-\Delta \varphi(x) - 2s v(x) \cdot \nabla \varphi(x) + c(x) \varphi(x) = \lambda(d, s) \varphi(x)$$
 Firstly, we constructed an infinitely oscillating gradient advection term such that the principal eigenvalue does not converge as $s \rightarrow +\infty$. Secondly, we considered the principal eigenvalue of the elliptic operator with a constant advection term and the boundary conditions $\varphi'(0) = s(1 + b_0)\varphi(0)$ and $\varphi'(1) = s(1 - b_1)\varphi(1)$ in one dimension. Then we determined the limits of these principal eigenvalues as s tends to infinity for all parameters $b_0, b_1 \in (-\infty, +\infty)$. Recently, we have further investigated the asymptotic eigenvalue problem on manifolds and obtained some results.

A Liouville-Type Theorem for the Weighted Higher-Order Elliptic System with Navier Boundary Conditions

Schedule: July 7 9:00-9:30 Room 311

Weiwei Zhao

Hainan University, Peoples Rep of China

Co-Author(s): Xiaoling Shao, Changhui Hu, Zhiyu Cheng

Abstract:

In this talk, we present a Liouville-type theorem for a weighted higher-order elliptic system, which holds in a wider range of exponents characterized by a critical curve. Our approach consists of two main steps. First, we establish a corresponding Liouville-type result for the associated integral system. Then, using superharmonic properties of the differential system, we show the equivalence between the elliptic system and the integral system. This extends and improves existing results in the literature.

Spreading speeds of nonlocal Fisher-KPP equations in heterogeneous media

Schedule: July 7 9:30-10:00 Room 311

Tao Zhou

Anhui University, Peoples Rep of China

Abstract:

Spreading speeds of nonlocal Fisher-KPP equations in heterogeneous media will be presented, including both temporally and spatially heterogeneous cases. The characterization of the speeds relies on the generalized principal eigenvalue and time averaging, respectively. In addition, some interesting examples will be introduced.

Special Session 56 : Dynamical properties of nonlinear partial differential equations

Organizer(s): Runzhang Xu , Andreas Chatziazfratis , Wei Lian

Introduction: The session will present some recent advances in the mathematical analysis of nonlinear partial differential equations and dynamical behaviors of solutions. Topics include global quantitative stability of wave equation, well-posedness theories of nonlinear evolution systems, and some related stability and existence results to PDEs.

Steady pattern formation and film rupture in a two-dimensional thermocapillary thin-film model of the Bénard--Marangoni problem

Schedule: July 9 9:00-9:30 Room 640

Stefano Boehmer

Lund University, Sweden

Co-Author(s): Bastian Hilder, Jonas Jansen

Abstract:

It is experimentally known that thin films of viscous fluids on heated plates develop polygonal, spatially periodic patterns. This is due to a self-sustaining thermocapillary effect causing an instability of the trivial constant state. Building upon a previous work on the one-dimensional case, we consider a two-dimensional thin-film equation. It can be formally derived from the Bénard--Marangoni problem via a long-wave approximation. We consider the stationary problem, which we are able to reduce to a second-order equation amenable to analytic bifurcation theory. The constant solution destabilizes via a (conserved) long-wave instability and we prove existence of a global bifurcation branch of stationary solutions of fixed mass, which are symmetric and periodic with respect to a fixed square or hexagonal lattice. We finally analyse qualitative aspects of the solutions on the branch both analytically and numerically. Most importantly, we prove that solutions exhibit film rupture, that is, their minimal height tends to zero, under the condition that the Marangoni number is uniformly bounded on the bifurcation branch. This conditional result is substantiated by numerical experiments. This is joint work with Bastian Hilder and Jonas Jansen.

A plethora of fully localised solitary waves for the full-dispersion Kadomtsev-Petviashvili equation

Schedule: July 9 8:30-9:00 Room 640

Mats Ehrnstrom

NTNU Norwegian University of Science and Technology, Norway

Co-Author(s): M. D. Groves, Saarland University

Abstract:

The KP-I equation arises as a weakly nonlinear model equation for gravity-capillary waves with Bond number $\beta > 1/3$ also called strong surface tension. This equation has recently been shown to have a family of nondegenerate, symmetric fully localised solitary waves which decay to zero in all spatial directions. The full-dispersion KP-I equation is obtained by retaining the exact dispersion relation in the modelling from the water-wave problem. In this paper we show that the FDKP-I equation also has a family of symmetric fully localised solitary waves which are obtained by casting it as a perturbation of the KP-I equation and applying a suitable variant of the implicit-function theorem.

Convective Stability of Front Superpositions: The Role of Unstable Connecting States

Schedule: July 9 9:30-10:00 Room 640

Bastian Hilder

Technical University of Munich, Germany

Co-Author(s): Louis Gar\`{e}naux

Abstract:

In pattern-forming systems, an unstable 'trivial' state is often first invaded by stripe patterns, which are themselves unstable to hexagonal patterns that emerge through a secondary (slower) invasion front. Such cascading invasions naturally give rise to a non-steady (i.e., the fronts travel at different speeds) two-front superposition in which the connecting state is unstable. In this talk, I present recent results on the linear convective stability of such a superposition of two travelling waves with unstable connecting state in a reaction-diffusion system. We find that convective stability holds for a strictly smaller range of propagation speeds than for the corresponding single-front waves, reflecting the long-range influence the fronts exert on one another. Since the superposition is time-dependent, classical techniques are not applicable to analyse this phenomenon. We therefore rely on numerical range estimates that imply time-uniform resolvent bounds. I will also discuss open challenges in the nonlinear analysis. This is joint work with Louis Gar\`{e}naux (INRIA Saclay).

Full Benjamin-Feir instability of capillary-gravity Stokes waves

Schedule: July 9 13:30-14:00 Room 640

Ting-Yang Hsiao

SISSA, Taiwan

Co-Author(s): Alberto Maspero

Abstract:

We study the modulational (Benjamin-Feir) instability of small-amplitude periodic Stokes waves for the two-dimensional gravity-capillary water waves equations. We analyze the spectral stability of such waves under long-wave longitudinal perturbations. The linearized operator exhibits a defective zero eigenvalue of multiplicity four due to the symmetries of the system. Using Bloch-Floquet theory, we investigate the associated family of periodic spectral problems and obtain a complete description of the eigenvalues near the origin in the small-amplitude regime. We prove that the four eigenvalues undergo a full splitting and rigorously characterize the transition between stability and instability. In the unstable regime, the spectrum near the origin forms the characteristic Figure 8 pattern associated with Benjamin-Feir instability, while in the stable regime it remains purely imaginary.

Capillary drops with constant vorticity

Schedule: July 9 14:30-15:00 Room 640

Giuseppe La Scala

Scuola Superiore Meridionale, Italy

Co-Author(s): Pietro Baldi, Domenico Angelo La Manna

Abstract:

We consider the problem of capillary liquid 2D and 3D capillary drops with the presence of constant vorticity. In the 2D case, we show that the problem is well-posed, the rotating circle solution is energetically stable and about it, small oscillations like rotating waves are produced. In the 3D case, we show that if capillary effects are stronger than vorticity ones and the equatorial section of the drop is strictly convex, then the drop is a surface of revolution.

The Fourier spectral approach to the spatial discretization of quasilinear hyperbolic systems

Schedule: July 9 15:00-15:30 Room 640

JOHANNA MARSTRANDER

NTNU - Norwegian University of Science and Technology, Norway

Co-Author(s): Vincent Duch\^{\e}ne

Abstract:

We will discuss the rigorous justification of the numerical spatial discretization by means of Fourier spectral methods of equations modelling the dynamical evolution of surface gravity waves. The Fourier spectral method is especially indicated for systems such as the Boussinesq and Whitham-Boussinesq systems since the nonlinear contributions are quadratic and dispersive contributions take the form of Fourier multipliers. The spatial discretization amounts to considering the modified PDE with low-pass filters for wave numbers $|k| \leq N$ applied to the initial data and nonlinear terms. Earlier convergence results for the discretization of Boussinesq systems have the shortcoming that they lack uniformity in the non-dispersive limit. Overcoming this requires a good understanding of the underlying (non-dispersive) quasilinear system, which will be the focus of the talk. Using energy estimates, we investigate the stability and convergence of the approximate solution as $N \rightarrow \infty$. The results depend on the regularity of the initial data and the structure of the system. We consider both sharp- and smooth low-pass filters and argue that - at least theoretically - smooth low-pass filters are operable on a larger class of systems.

Decay structure of an inviscid non-equilibrium radiation hydrodynamics system

Schedule: July 9 8:00-8:30 Room 640

Ramon G. Plaza

Universidad Nacional Autonoma de Mexico, Mexico

Co-Author(s): Corrado Lattanzio, Jose M. Valdovinos

Abstract:

In this talk I will examine the diffusion approximation, non-equilibrium model of radiation hydrodynamics derived by Buet and Despr\^{\e}s (J. Quant. Spectrosc. Radiat. Transf. 85, 2004). The latter describes a non-relativistic inviscid fluid subject to a radiative field under the non-equilibrium hypothesis, that is, when the temperature of the fluid is different from the radiation temperature. It is shown that local solutions exist for the general system in several space dimensions. It is also proved that only the one-dimensional model is genuinely coupled in the sense of Kawashima and Shizuta. A notion of entropy function for non-conservative parabolic balance laws is also introduced. It is shown that the entropy identified by Buet and Despr\^{\e}s is an entropy function for the system in the latter sense. This entropy is used to recast the one-dimensional system in terms of a new set of perturbation variables and to symmetrize it. With the aid of genuine coupling and symmetrization, decay rates for solutions to the one dimensional linearized problem are obtained; these estimates, combined with the local existence result, yield the global existence and decay in time of perturbations of constant equilibrium states in one space dimension. This is joint work with Corrado Lattanzio (L'Aquila) and Jose M. Valdovinos (Toulouse).

Rediscovering shallow-water equations from experimental data

Schedule: July 9 15:30-16:00 Room 640

Douglas Svensson Seth

Norwegian University of Science and Technology, Sweden

Co-Author(s): Kjell Heinrich, Mats Ehrnstrom, Simen Ellingsen

Abstract:

While data-driven methods have advanced the discovery of governing equations, extracting robust partial differential equations from real-world data remains challenging. Here we present a Fourier-based approach to rediscover a shallow water-equation akin to the Korteweg-De Vries (KdV) equation using only video footage of solitons. The Fourier-multiplier technique is also compared to another distinct method, weak-form sparse identification of nonlinear dynamics (WSINDy), which independently recover the same PDE, confirming its inherent structure in the data. We validate the discovered equation by solving it forward and comparing it to unseen experimental cases.

Three-dimensional doubly periodic gravity water waves on Beltrami flows

Schedule: July 9 14:00-14:30 Room 640

Erik Wahl`en

Lund University, Sweden

Co-Author(s): Mark Groves, Dag Nilsson, Stefano Pasquali

Abstract:

I will present an existence result for small-amplitude doubly periodic travelling gravity water waves on Beltrami flows, a class of rotational flows in which the velocity field is parallel to the vorticity. This extends the existence theory by Iooss and Plotnikov in the irrotational setting. The problem is technically challenging due to the appearance of small divisors. We overcome this by using a Nash--Moser theorem. I will highlight the key differences and new issues that appear in the Beltrami setting.

Mixed type problem and transonic flows

Schedule: July 9 16:30-17:00 Room 640

Dehua Wang

University of Pittsburgh, USA

Abstract:

In this talk, we will consider the Euler equations of gas dynamics and applications in transonic flows. We will present the results on the transonic flows past obstacles, transonic flows in the fluid dynamic formulation of isometric embeddings, and the transonic flows in nozzles.

Mountain waves: Linear theory

Schedule: July 9 17:00-17:30 Room 640

Jörg Weber

University of Vienna, Austria

Abstract:

In this talk, I will discuss the linear theory of mountain waves in two dimensions. After an introduction to the physical relevance and the typically observed wave patterns, we turn to the underlying boundary value problem for the compressible Euler equations coupled to the ideal gas law and the first law of thermodynamics. In particular, we are interested in their linearization at a background state, corresponding to an incoming horizontal wind profile. We show how the linearized equations can be reduced to a Helmholtz-like equation (the Scorer equation, well-known in the applied literature) for the vertical velocity on the upper-half plane. We then present a solution theory for the corresponding boundary value problem. Here, we have to pay special attention to a careful implementation of a physically correct radiation condition that is fundamentally different to typical radiation conditions à la Sommerfeld, which are relevant in the context of electromagnetic and acoustic waves, but physically incorrect for mountain waves. The talk is based on joint work with Adrian Constantin (U Vienna).

Statistics of long-crested crossing random waves over a varying bottom

Schedule: July 9 17:30-18:00 Room 640

Zibo Zheng

Okinawa Institute of Science and Technology, Japan

Co-Author(s): Zibo Zheng, Wooyoung Choi, Amin Chabchoub

Abstract:

The evolution of a unidirectional wave train on varying bathymetry is well documented while the statistics of crossing seas over uneven bottoms remain poorly understood. This work investigates the spatial evolution of skewness and kurtosis for weakly nonlinear random waves propagating over a slowly varying bottom. To model this complex process, we develop a system of coupled nonlinear Schrödinger equations that accounts for the interaction between two obliquely propagating wave trains and variation of water depth. We perform comprehensive numerical simulations using split-step Fourier method and initialize the representative wave field using the JONSWAP spectrum. By examining how the incident angle and bathymetry alter wave statistics, we ultimately demonstrate their combined influence on freak wave generation.

Special Session 58 : New developments in celestial mechanics and related topics

Organizer(s): Guowei Yu , Kuo-Chang Chen , Mitsuru Shibayama

Introduction: Despite its long history, celestial mechanics remains a highly active area of mathematics, with many exciting developments in recent years. These advances span diverse topics, including periodic solutions, central configurations, stability, final motions, chaotic behavior, and more, employing techniques from algebraic, topological, variational and computational methods. In this special session, we aim to bring together experts in these fields to share their latest results and exchange new ideas.

Rigidity for Kepler billiards

Schedule: July 8 9:30-10:00 Room 827

Stefano Baranzini

Universita San Raffaele Roma, Italy

Co-Author(s): Vivina Barutello, Irene De Blasi, Susanna Terracini

Abstract:

A point mass moves inside a planar convex domain under the gravitational attraction of a fixed positive mass. Upon reaching the boundary, the particle is reflected back inside the domain according to the geometric optics law: the angle of incidence equals the angle of reflection. It is known that this dynamical system is integrable (for all energy levels) when for instance the boundary is an ellipse and the attracting mass is placed at one of its foci. In this talk we will discuss the following rigidity phenomenon: among analytic, centrally symmetric, compact convex domains, the only ones for which the corresponding Kepler billiard is analytically integrable (at least for sufficiently large energies) are circles with the attracting mass placed at their centres and ellipses, with the attracting mass at a focus. Our approach is based on an explicit construction of a symbolic dynamics for the system.

The 2-homogeneous 2-centre problem: symbolic dynamics and scattering

Schedule: July 8 9:00-9:30 Room 827

Gian Marco Canneori

University of Turin, Italy

Abstract:

In this talk we consider two attraction centres $c_1, c_2 \in \mathbb{R}^2$ and study the dynamics of a particle $q \in \mathbb{R}^2 \setminus \{c_1, c_2\}$ under the action of a singular potential function U which has the following prescribed behaviour close to each centre

$$U(q) \sim \frac{m_j}{|q - c_j|^2}, \quad m_j > 0, \quad q \in \mathcal{U}(c_j).$$

We fix a positive value of the mechanical energy and we construct infinitely many periodic solutions in distinct homotopy classes, all avoiding collisions with the centres. We then investigate the existence of invariant sets that are topologically conjugate with the Bernoulli shift. Finally, we analyse the asymptotic behaviour of unbounded trajectories and discuss the existence of scattering solutions with prescribed topological behaviour with respect to the centres. This is a joint work with Stefano Baranzini and Alberto Boscaggin.

Periodic dynamics in the perturbed relativistic Kepler problem

Schedule: July 8 8:00-8:30 Room 827

Guglielmo Feltrin

University of Udine, Italy

Abstract:

The motion of a relativistic particle in a Kepler potential can be described by the equation
$$\frac{d}{dt} \left(\frac{m \dot{x}}{\sqrt{1 - |\dot{x}|^2/c^2}} \right) = -\alpha \frac{x}{|x|^3}, \quad x \in \mathbb{R}^3 \setminus \{0\},$$
 where $m > 0$ represents the mass of the particle, c is the speed of light, and $\alpha > 0$ is a constant. Firstly, we illustrate the Hamiltonian formulation of the problem and we focus our attention on the description of the periodic and quasi-periodic solutions. Secondly, we deal with the perturbed equation
$$\frac{d}{dt} \left(\frac{m \dot{x}}{\sqrt{1 - |\dot{x}|^2/c^2}} \right) = -\alpha \frac{x}{|x|^3} + \varepsilon \nabla_x U(t, x), \quad x \in \mathbb{R}^3 \setminus \{0\},$$
 where $U(t, x)$ is T -periodic in the first variable and $\varepsilon \in \mathbb{R}$. We present some results concerning the existence of periodic orbits obtained in collaboration with Alberto Boscaggin (University of Torino), Walter Dambrosio (University of Torino), and Duccio Papini (University of Modena and Reggio Emilia).

On the Arnold diffusion mechanism in Medium Earth Orbit

Schedule: July 8 8:30-9:00 Room 827

Mar Giralt

Observatoire de Paris - Universite PSL, France

Co-Author(s): E.M Alessi, I. Baldoma and M. Guardia

Abstract:

Motivated by the need of preserving the operational orbital regions around the Earth, natural perturbations can be exploited to lead satellites towards atmospheric reentry at the end of life. In the case of the Medium Earth Orbit (MEO) region the main driver is the third-body perturbation. In this work, we show how an Arnold diffusion mechanism can trigger the eccentricity growth in MEO, so that the pericenter altitude drops into the atmospheric drag domain. Focusing on the case of Galileo, we consider a hierarchy of Hamiltonian models, assuming that the main perturbations are the oblateness of the Earth and the gravitational attraction of the Moon. First, the Moon is assumed to lay on the ecliptic plane and periodic orbits and associated stable and unstable invariant manifolds are computed for various energy levels, in the neighborhood of a given resonance. Along each invariant manifold, the eccentricity increases naturally, achieving its maximum at the first intersection between them. This growth is, however, not sufficient to achieve reentry. By moving to a more realistic model, where the inclination of the Moon is taken into account, the problem becomes non-autonomous and the satellite is able to move along different energy levels.

On the Sundman-Sperling estimates for the restricted one-center-two-body problem

Schedule: July 7 18:00-18:30 Room 827

Ku-Jung Hsu

School of Mathematical Sciences Huaqiao University, Peoples Rep of China

Co-Author(s): Lei Liu

Abstract:

In the past two decades, since the discovery of the figure-8 orbit by Chenciner and Montgomery, the variational method has become one of the most popular tools for constructing new solutions of the N -body problem and its extended problems. However, finding solutions to the restricted three-body problem, in particular, the two primaries form a collision Kepler system, remains a great difficulty. One of the major reasons is the essential differences between two-body collisions and three-body collisions. In this paper, we consider a similar three-body system with less difficulty, i.e. the restricted one-center- two-body system, that is involving a massless particle and a collision Kepler system with one body fixed. It is an intermediate system between the restricted three-body problem and the two-center problem. By an in-depth analysis to the asymptotic behavior of the minimizer, and an argument concerning critical and inflection points, we prove the Sundman-Sperling estimates near the three-body collision for the minimizers. With these estimates, we provide a class of collision-free solutions with prescribed boundary angles. Finally, under the extended collision Kepler system from Gordon, we construct a family of periodic and quasi-periodic solutions.

Bifurcations of highly inclined near halo orbits using Moser regularization

Schedule: July 8 14:30-15:00 Room 827

Chankyu Joung

Seoul National University, Korea

Co-Author(s): Dayung Koh, Otto van Koert

Abstract:

We study the bifurcation structure of highly inclined near halo orbits with close approaches to the light primary, in the circular restricted three-body problem (CR3BP). Using a Hamiltonian formulation together with Moser regularization, we develop a numerical framework for the continuation of periodic orbits and the computation of their Floquet multipliers which remains effective near collision. We describe vertical collision orbits and families emerging from its pitchfork, period-doubling, and period-tripling bifurcations in the limiting Hill's problem, including the halo and butterfly families. We continue these into the CR3BP using a perturbative framework via a symplectic scaling, and construct bifurcation graphs for representative systems (Saturn--Enceladus, Earth--Moon, Copenhagen) to identify common dynamical features. Conley--Zehnder indices are computed to classify the resulting families. Together, these results provide a coherent global picture of polar orbit architecture near the light primary, offering groundwork for future mission design, such as Enceladus plume sampling missions. This is joint work with Dayung Koh and Otto van Koert.

Hamiltonian systems and monotone twist mappings for braids

Schedule: July 8 15:00-15:30 Room 827

Yuika Kajihara

Kyoto University, Japan

Co-Author(s): Mitsuru Shibayama

Abstract:

One of the open problems in the N-body problem is the following: for any given pure braid, does there exist a periodic solution that realizes it? As a more fundamental question, one may ask whether, for any given braid, there exists a Hamiltonian system that realizes it in the first place. In 1986, Moser showed that for a given area-preserving map, there exists a Hamiltonian system that realizes it as a Poincaré map. Using his technique, we prove that for any braid, there exists a Hamiltonian system whose orbits realize the given braid. In particular, when the braid is pseudo-Anosov, the corresponding Poincaré map is also pseudo-Anosov.

A study of braids arising from simple choreographies of the planar Newtonian N-body problem

Schedule: July 8 14:00-14:30 Room 827

Eiko Kin

The University of Osaka, Japan

Co-Author(s): Yuika Kajihara and Mitsuru Shibayama

Abstract:

We study periodic solutions of the planar Newtonian N-body problem with equal masses. Each periodic solution traces out a braid with N strands in 3-dimensional space. According to the Nielsen-Thurston classification of surface automorphisms, braids can be classified into three types: periodic, reducible, and pseudo-Anosov. When a braid is of pseudo-Anosov type, it has an associated stretch factor greater than 1, which reflects the complexity of the periodic solution. For each $N \geq 3$, Guowei Yu established the existence of a family of simple choreographies to the planar Newtonian N-body problem. We prove that braids arising from Yu's periodic solutions are of pseudo-Anosov types, except in the special case where all particles move along a circle. We also identify the simple choreographies whose braid types have the largest and smallest stretch factors, respectively.

Birkhoff sections for integrable flows on 3-manifolds

Schedule: July 7 17:30-18:00 Room 827

Wentian Kuang

Great Bay University, Peoples Rep of China

Abstract:

Birkhoff sections (or global surfaces of section) are an important tool in the study of Hamiltonian systems. In this talk, we present a method for directly constructing Birkhoff sections for integrable flows on 3-manifolds. The construction can be applied to boundaries of toric domains and energy surfaces of separable Hamiltonian systems, providing criteria for the existence or non-existence of certain types of Birkhoff sections.

Existence of Really Perverse Central Configurations in the Spatial N-Body Problem

Schedule: July 8 15:30-16:00 Room 827

Mitsuru Shibayama

Kyoto University, Japan

Abstract:

We construct explicit examples of really perverse central configurations in the spatial Newtonian N -body problem. A central configuration is called really perverse if it satisfies the central configuration equations for two distinct mass distributions having the same total mass. While such configurations were previously known only in the planar case for large N , we prove the existence of spatial really perverse central configurations for $N = 27, \dots, 55$.

Floer homology and the restricted three body problem

Schedule: July 8 13:30-14:00 Room 827

Otto van Koert

Seoul National University, Korea

Co-Author(s): Chankyu Joung, Dayung Koh

Abstract:

We discussed several versions of Floer homology, including local Floer homology and symplectic homology, which we apply to study periodic orbits in the restricted three-body problem. We discussed bifurcations. Some theoretical results and some numerical results, obtained jointly with Chankyu Joung and Dayung Koh.

On the vanishing viscosity limit of Hamilton-Jacobi equations.

Schedule: July 7 16:30-17:00 Room 827

Jianlu ZHANG

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

In this talk we present a convergence of solutions for the vanishing viscosity process of Hamilton-Jacobi equations with nearly optimal discounted rate. Such a result partially answered the problem proposed by Evans in 2003 AIM workshop.

A KAM Theorem for the Anisotropic Heisenberg Chain with Quasi-Periodic Coupling

Schedule: July 7 17:00-17:30 Room 827

Lei Zhang

Dalian University of Technology, Peoples Rep of China

Co-Author(s): Xifeng Su

Abstract:

We establish a KAM theorem for constructing analytic quasi-periodic equilibrium configurations in the classical anisotropic Heisenberg XYZ spin chain with quasi-periodic coupling and a small external magnetic field. The equilibrium equations reduce to a second-order nonlinear matrix difference equation with quasi-periodic coefficients. By introducing auxiliary parameters and employing a factorization method, we reformulate the problem into two first-order equations. Under Diophantine conditions on the frequency and appropriate non-degeneracy assumptions, we prove the existence of analytic quasi-periodic solutions via a Nash-Moser iteration scheme. The proof relies on solving twisted cohomology equations and a reducibility lemma. As an application, we obtain the existence of quasi-periodic spin patterns for the Heisenberg XYZ model with small quasi-periodic perturbations.

Special Session 63 : Interdisciplinary Applications of Traditional Numerical Methods, Deep Learning Methods, and Statistical Approaches

Organizer(s): Qiaolin He , Xiaoling Peng

Introduction: This session focuses on the combined application of traditional numerical methods, deep learning techniques, and statistical approaches to tackle real-world problems. Traditional numerical methods offer rigorous and precise solutions for complex mathematical models, while deep learning provides powerful tools for pattern recognition and prediction from large datasets. Statistical methods, on the other hand, enable effective data analysis and uncertainty quantification. By integrating these three approaches, we can leverage their respective strengths to address challenges in diverse fields such as engineering, finance, healthcare, and environmental science. This session will include case studies demonstrating successful integrations, discussions on overcoming integration challenges, and opportunities for collaborative problem-solving. Participants will gain insights into how this multidisciplinary approach can enhance our ability to solve practical problems more efficiently and accurately.

Well-balanced positivity-preserving high-order discontinuous Galerkin methods for Euler equations with gravitation

Schedule: July 6 14:30-15:00 Room 440

Jie Du

East China Normal University, Peoples Rep of China

Co-Author(s): Yu Wang, Yang Yang and Fangyao Zhu

Abstract:

We develop high order discontinuous Galerkin (DG) methods with Lax-Friedrich fluxes for Euler equations under gravitational fields. Such problems may yield steady-state solutions and the density and pressure are positive. There were plenty of previous works developing either well-balanced (WB) schemes to preserve the steady states or positivity-preserving (PP) schemes to get positive density and pressure. However, it is rather difficult to construct WB PP schemes with Lax-Friedrich fluxes, due to the penalty term in the flux. In fact, for general PP DG methods, the penalty coefficient must be sufficiently large, while the WB scheme requires that to be zero. This contradiction can hardly be fixed following the original design of the PP technique. In this talk, we reformulate the source term such that it balances with the flux term when the steady state has reached. To obtain positive numerical density and pressure, we choose a special penalty coefficient in the Lax-Friedrich flux, which is zero at the steady state. The technique works for general steady-state solutions. Numerical experiments are given to show the performance of the proposed methods.

Fast solvers for numerical simulations with applications in microfluidics and antenna design

Schedule: July 6 17:30-18:00 Room 440

Shihua Gong

The Chinese University of Hong Kong, Shenzhen, SICIAM and SLAI, Peoples Rep of China

Abstract:

Many modern technologies - such as wireless communication devices and microfluidic chips - rely on large-scale numerical simulations. In these simulations, solving the underlying algebraic systems often takes most of the computing time. In this talk, I will introduce several ideas that help accelerate two types of simulations arising from antenna electromagnetics and microfluidic flows.

A GPU-Accelerated Matrix-Free FAS Multigrid Solver with Memory-Efficient Implementations

Schedule: July 6 16:30-17:00 Room 440

Zhenlin Guo

Beijing Computational Science Research Center, Peoples Rep of China

Abstract:

We develop a matrix-free Full Approximation Storage (FAS) multigrid solver based on staggered finite differences and implemented on GPU in MATLAB. To enhance performance, intermediate variables are reused, and an X-shape Multi-Color Gauss-Seidel (X-MCGS) smoother is introduced. This scheme eliminates the conditional branching required to distinguish red and black nodes in the standard two-color Red-Black Gauss-Seidel (RBGS) method by partitioning the grid into four submatrices according to row-column parity. In addition, restriction and prolongation operators are implemented with GPU acceleration.

Well-balanced and entropy-stable nodal DG method for the Euler equations with gravity

Schedule: July 6 15:00-15:30 Room 440

Yan Jiang

University of Science and Technology of China, Peoples Rep of China

Abstract:

We propose an entropy stable and well-balanced discontinuous Galerkin (DG) scheme for the Euler equations with gravity. To achieve these properties, we utilize the nodal DG framework and carefully design the source term discretization using entropy conservative fluxes. In addition, the proposed formulation is carefully designed to ensure compatibility with a positivity-preserving limiter. We provide a rigorous theoretical analysis to establish the accuracy and structure-preserving properties of the proposed scheme. Extensive numerical experiments confirm the robustness and efficiency of the scheme.

Energy Dissipation Preservation of Implicit-Explicit Linear Multistep Methods for Gradient Flows

Schedule: July 6 17:00-17:30 Room 440

Chaoyu Quan

The Chinese University of Hong Kong (Shenzhen), Peoples Rep of China

Abstract:

This paper proposes a theoretical framework for establishing the energy dissipation of general implicit-explicit linear multistep methods (IMEX-LMMs) for gradient flows, by constructing a dissipative modified energy consisting of the original energy and a non-negative quadratic modification. We first test IMEX-LMMs with the first-order time difference of numerical solutions. Then, it is shown that the associated non-negative quadratic modification can be constructed if and only if two generating polynomials (corresponding to the LMM) are positive on $[-1, 1]$. Based on this, the modified energy is proved to decay over time under a mild time-step restriction depending on the lower bounds of the associated generating polynomials. As a consequence, the energy dissipation of the well-known backward differentiation formula methods up to fifth order can be obtained straightforwardly. Furthermore, we construct for the first time (to the best of our knowledge) a sixth-order energy-dissipative IMEX-LMM and also prove the sixth-order barrier of energy-dissipative IMEX-LMMs. Some numerical experiments are conducted to verify our theoretical results.

Randomized Neural Networks for PDEs

Schedule: July 6 14:00-14:30 Room 440

Fei Wang

Xi'an Jiaotong University, Peoples Rep of China

Abstract:

Traditional numerical methods are mathematically rigorous, highly accurate, and physically conservative, forming the reliable foundation of modern scientific computing. Despite their success, they still face intrinsic challenges such as the need for complex mesh generation, limited flexibility in representing global structures, case-by-case reassembly for new configurations, the curse of dimensionality, and difficulties in integrating data or uncertainty. Neural network-based numerical methods have recently emerged as an alternative paradigm, aiming to overcome these limitations through their strong representation capability. However, traditional training-based neural approaches often suffer from the challenges of nonlinear, nonconvex optimization, resulting in limited accuracy and efficiency. To address these issues, we propose a family of randomized neural network (RaNN) methods that integrate the mathematical rigor of classical numerical schemes with the flexibility of neural representations. The framework includes the RaNN-Petrov-Galerkin (RaNN-PG), Local RaNN-Discontinuous Galerkin (LRaNN-DG), LRaNN-HDPG, and LRaNN-Finite Difference methods. Furthermore, an Adaptive-Growth RaNN (AG-RaNN) strategy is introduced to optimize the weighting and selection of random parameters dynamically. We also explore RaNNs for accelerating operator learning, enabling faster training for parameterized PDEs. Numerical experiments demonstrate that RaNN-based methods achieve high accuracy with few degrees of freedom while remaining mesh-free, structure-preserving, and easily extendable to high-dimensional and time-dependent problems. These results highlight RaNNs as a promising direction for unifying classical numerical methods and modern machine learning in the efficient solution of PDEs.

Mechanics-Informed Inverse Design and Optimization for Wrinkle Control in Fiber-Reinforced Bilayers

Schedule: July 6 18:00-18:30 Room 440

Xinyu WANG

Beijing Normal-Hong Kong Baptist University, Peoples Rep of China

Co-Author(s): Xiaoyi Chen, Hao Wang, Peijun Gan, Junlong Dai, Tianyu Shu, Yuxuan Chen, Fanze Yang, Yongtao Lyu

Abstract:

Controlling wrinkling in fiber-reinforced bilayers is critical for applications from anti-aging skincare to skin substitutes. While forward predictions are well-developed, efficient optimization and inverse-design strategies targeting microstructural controls---such as fiber pretension and orientation---remain limited. We develop a mechanics-informed framework to tune wrinkle onset and morphology in a skin-inspired bilayer. Using a semi-analytical morphoelastic plate model, we quantify how five design variables $(h, K, \beta, \lambda f, \phi f)$ govern the critical wrinkling threshold g_{10}^* and mode number n^* . This reduced-order formulation enables high-throughput exploration up to $\phi f = 0.85$, providing a computational basis for large-scale optimization challenging for standard 3D finite element simulations. Global sensitivity and mechanical perturbation analyses identify fiber pretension as the dominant regulator of g_{10}^* , while n^* is primarily controlled by thickness and orientation. For optimal inverse design, we implement two complementary routes: (i) a regularized mechanics-based optimization leveraging semi-analytical stability conditions, and (ii) a surrogate-assisted search (BPNN--GA) for global scalability. The resulting designs provide physics-consistent tuning strategies for aging skin models, offering quantitative guidance for personalized, skin-inspired material design.

Deep learning methods for singular variational problems with Lavrentiev phenomena

Schedule: July 6 13:30-14:00 Room 440

Xianmin XU

Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Dong Wang, Boyi Zou

Abstract:

Deep learning has gained significant development in the field of scientific computing, especially in its application to solve problems related to differential operators using deep neural networks. However, the utilization of neural networks to solve problems involving singularities still faces challenges. In this talk, we will discuss the failure of deep learning methods for the singular variational problems exhibiting the Lavrentiev phenomenon. For such problems, we show the standard deep Ritz method and some variants fail to detect the singular minimizers. We then introduce a guiding term that renders the neural network to explore solutions as desired during training. Numerical experiments demonstrate that the method achieves much better approximations than the previous methods. Furthermore, we apply the same algorithm to solve problems with regular solutions to show the robustness of the proposed method.

Electrically controlled self-similar evolution of viscous fingering patterns

Schedule: July 6 15:30-16:00 Room 440

Meng Zhao

Huazhong University of Science and Technology, Peoples Rep of China

Abstract:

In this talk, we investigate the nonlinear dynamics of a moving interface in a Hele-Shaw cell subject to an in-plane applied electric field. We develop a spectrally accurate boundary integral method where a coupled integral equation system is formulated. Our nonlinear results reveal that positive currents restrain finger ramification and promote overall stabilization of patterns. On the other hand, negative currents make the interface more unstable and lead to the formation of thin tail structures connecting the fingers and a small inner region. When no flux is injected, and a negative current is utilized, the interface tends to approach the origin and break up into several drops. We investigate the temporal evolution of the smallest distance between the interface and the origin and find that it obeys an algebraic law.

Abstracts for Special Sessions

Special Session 64 : Reaction-diffusion equations and applications

Organizer(s): Wan-Tong Li , Zhi-Cheng Wang , Shi-Liang Wu

Introduction: Many problems in physics, chemistry and biology can be described using reaction-diffusion equations. The analysis of their dynamical behavior has always been a fundamental issue in the fields of differential equations, dynamical systems, and their applications. This special session focuses on theory, methods and applications of reaction-diffusion equations. Related topics are spatial propagation, pattern formation, free boundary problem and asymptotic behavior of solutions in reaction-diffusion equations and applications in biology.

Uniform regularity estimates and inviscid limit for the compressible non-resistive magnetohydrodynamics system

Schedule: July 9 9:00-9:30 Room 637

Xiufang Cui

Lanzhou University, Peoples Rep of China

Abstract:

We are concerned with the uniform regularity estimates of solutions to the two dimensional compressible non-resistive magnetohydrodynamics equations with the no-slip boundary condition on velocity in the half plane. Under the assumption that the initial magnetic field is transverse to the boundary, the uniform conormal energy estimates are established for the solutions to compressible MHD equations with respect to the small viscosity coefficient. As a direct consequence, we proved the inviscid limit of solutions from viscous MHD equations to the ideal MHD system by some compact argument.

Accelerating propagation in diffusion phenomena

Schedule: July 9 9:30-10:00 Room 637

Wan-Tong Li

Lanzhou University, Peoples Rep of China

Abstract:

In this talk, we focus on the accelerating propagation in diffusion phenomena. It is well-known that the solution of a monostable nonlocal dispersal scalar equation spreads at a finite speed when the kernel is light-tailed and propagates by accelerating when the kernel has a heavy-tail. However, in such systems, we find that one species can propagate by accelerating although its dispersal kernel is light-tailed, which is a new and interesting phenomenon. In particular, the accelerating phenomenon also has been found in nonlocal free boundary problems and in shifting environments.

Persistence and Spatial Propagation of an Impulsive Integro-differential System with Non-local Pulse

Schedule: July 9 8:00-8:30 Room 637

Jiabing Wang

China University of Geosciences (Wuhan), Peoples Rep of China

Abstract:

In order to investigate the spatial distribution and evolution dynamics of populations exhibiting synchronized reproduction and two stage long-distance dispersal modes, we propose an impulsive integro-differential system with non-local pulse. Firstly, we establish the extinction and persistence dynamics on the bounded domain with Dirichlet boundary of non-local type. Secondly, we derive the existence and characterization of the spreading speed in the whole space as well as the consistency with the minimum wave speed of the traveling waves in the case where the kernels are exponentially bounded. Thirdly, we study the accelerated propagation in the case where the dispersal kernel or pulse kernel is exponentially unbounded.

Spreading speeds of a nonlocal diffusive epidemic model with a new weight-type free boundary condition

Schedule: July 8 16:30-17:00 Room 637

Rong Wang

Lanzhou University, Peoples Rep of China

Co-Author(s): Xin Long

Abstract:

This talk is concerned with the spreading behavior of a nonlocal epidemic model with new weight-type free boundary conditions. Such conditions were originally introduced for the Fisher-KPP equation in Du et al. (submitted, 2024), and they are used here to describe the expansion of the epidemic region under weighted population effects. This work continues a previous study by Long and Wang (submitted, 2026), in which the model was shown to be well posed and to exhibit a spreading-vanishing dichotomy in its long-time dynamics, together with a threshold condition for finite spreading speed. The main focus of this talk is the accelerated spreading case, where the spreading speed is infinite. For some typical classes of kernel and weight functions, I will present the precise rates of accelerated expansion of the epidemic region. This talk is based on joint work with Dr. Xin Long.

Long time behavior for Lotka-Volterra competition-diffusion systems

Schedule: July 8 17:30-18:00 Room 637

Shi-Liang Wu

xidian university, Peoples Rep of China

Abstract:

In this talk, we first introduce some known results on long time behavior of bounded solutions for reaction-diffusion equations. Then, we present our recent results on the long time behavior to Lotka-Volterra competition-diffusion systems.

The propagation dynamics for a class of time-period SIAR system with nonlocal dispersal and delay

Schedule: July 8 17:00-17:30 Room 637

Yun-Rui Yang

Lanzhou Jiaotong University, Peoples Rep of China

Co-Author(s): Meng-Xuan Jia

Abstract:

In this talk, the propagation dynamics for a class of time-period SIAR system with nonlocal dispersal and delay are discussed. Firstly, the existence of asymptotic spreading speed is formed by the priori estimates, Arzela-Ascoli theorem, auxiliary systems and the uniform persistence idea for dynamical systems. Second, the existence of periodic traveling waves is established with the help of the non-compactness Kuratowski measure theory and the asymptotic fixed point theorem. Finally, the non-existence of periodic traveling waves is also obtained by a contradictory argument and analysis method.

Pullback measure random attractors of lattice FitzHugh-Nagumo systems

Schedule: July 8 18:00-18:30 Room 637

Weisong Zhou

School of Mathematics and Statistics, Chongqing University of Posts and Telecommunications,, Peoples Rep of China

Abstract:

Revised Abstract: In this talk, we will investigate the existence of the pullback measure random attractor of stochastic FitzHugh-Nagumo equations in an infinite lattice with multiplicative white noise. Using the Ornstein-Uhlenbeck transform, we firstly show the existence of an absorbing set, then prove that the random dynamical system is asymptotically compact. Finally, the existence of the pullback measure random attractor is provided by constructing an invariant probability measure for the corresponding random dynamical system, which characterizes the long-term statistical behavior of the stochastic lattice system.

An impulsive reaction-diffusion model with asymptotically bounded domain

Schedule: July 9 8:30-9:00 Room 637

Min Zhu

Anhui Normal University, Peoples Rep of China

Co-Author(s): Min Zhu and Xiao-Qiang Zhao

Abstract:

In this talk, I will report our recent research on a continuous-discrete hybrid population model in a time-varying and asymptotically bounded domain. For the sake of analysis, this model is transformed into an impulsive reaction-diffusion system in a fixed domain. With the aid of the discrete-time semiflow generated by the solution maps of a limiting system and the theory of chain transitive sets, we establish the threshold-type results on the global dynamics of the model system in the cases of monotone and nonmonotone birth functions, respectively. Our explicit formula of the threshold value can help to understand how the final expansion factor of the habitat and the birth pulse rate affect the survival of population.

Special Session 65 : Geometry of PDEs on Manifolds and Nilpotent Lie Groups

Organizer(s): Jyotshana Prajapat , Pieralberto Sicbaldi

Introduction: The study of qualitative properties of solutions is a fundamental aspect of theory of partial differential equations. Classification of solutions plays a crucial role in proving existence results, deriving a priori estimates, establishing comparison principles, and more. When an equation exhibits invariance under certain transformations in the ambient space, one naturally expects its solutions to share this invariance. While various techniques have been developed in Euclidean geometry to analyze such properties, extending and adapting these methods to Manifolds and Nilpotent Lie groups presents new challenges, deeply influenced by the underlying geometric structure. Many of these geometric structures arise in the study of problems in Physics, Statistical Mechanics, Biology, Chemistry to name a few and are crucial for understanding the PDEs modelling the problems in these fields. This session aims to bring together researchers working on PDEs in the context of Riemannian and sub-Riemannian geometries, fostering discussions on recent advancements and open problems in the field.

Varadhan-type asymptotics for boundary data with localized support

Schedule: July 6 16:30-17:00 Room 301

Diego Berti

Univeristy of Turin, Italy

Abstract:

We study short-time and small-diffusion asymptotics for linear, uniformly elliptic operators with variable coefficients in a bounded domain. For nonconstant boundary data, we show that the leading behavior is governed by the intrinsic distance, induced by the operator, to the support of the boundary datum. This extends the classical Varadhan result, originally obtained for constant boundary data, and emphasizes the role of the localized source. This is joint work with Michele Marini (University del Sannio, Italy) and Rolando Magnanini (University di Firenze, Italy).

Qualitative properties of solutions to fractional elliptic and parabolic equations

Schedule: July 6 13:30-14:00 Room 301

Wenxiong Chen

Yeshiva University, USA

Abstract:

In this talk, we will present some of the recent developments in the study of qualitative properties of solutions to various fractional elliptic and parabolic equations

$$\mathcal{L}u = f(t, u(x, t)),$$

where $\mathcal{L}$ is a fractional elliptic or parabolic operator assuming one of the following forms

$$(\Delta)^s, \quad \partial_t + (-\Delta)^s, \quad \partial_t^\alpha + (-\Delta)^s, \quad (\partial_t - \Delta)^s.$$

We will illustrate the extent of non-locality of these operators and explain the differences among them. Then we will present some of our recent results on qualitative properties of solutions including monotonicity, symmetry, uniqueness, nonexistence, and a priori estimates.

Symmetry and rigidity results for Serrin's overdetermined type problems in weighted Riemannian manifolds

Schedule: July 6 14:00-14:30 Room 301

Giulio Ciraolo

University of Milan, Italy

Co-Author(s): Laura Accornero

Abstract:

We consider the classical Serrin's overdetermined boundary value problem in a weighted Riemannian manifold. Under suitable assumptions, we prove that the existence of a solution implies that the domain must be isometric to an Euclidean ball, also providing a rigidity result on the underlying manifold.

Rigidity results for spherical, as well as annular domains, in manifolds with pole

Schedule: July 6 14:30-15:00 Room 301

Antonio Greco

University of Cagliari, Italy

Co-Author(s): Marcello Lucia (New York), Pieralberto Sicbaldi (Granada)

Abstract:

Overdetermined problems for the rotationally invariant Poisson equation $-\Delta u = f(r)$ in a Riemannian manifold with pole O have been recently investigated (arXiv:2602.18289) by Marcello Lucia (New York), Pieralberto Sicbaldi (Granada) and the speaker. We give conditions on f and on the boundary data implying that the solution u is radial and the domain of the problem is a geodesic ball centered at O , or an annulus centered there. Our results hold, in particular, in the three space forms with constant curvature. Proofs are based on the comparison principle.

Huber's Theorems in Dimensions 2 and 4

Schedule: July 6 17:30-18:00 Room 301

Paul Laurain

University Gustave Eiffel, France

Co-Author(s): Dorian Martino

Abstract:

After recalling the classical statement of Huber's second theorem, I will propose an approach via the moving frame method. I will then present the state of the art on generalizations of this theorem to dimension 4, emphasizing that these do not yet yield a complete generalization. Next, drawing inspiration from the moving frame approach, we will present a new advance toward a full characterization. Finally, I will give some applications to the extrinsic case. Joint work with Dorian Martino.

Concentration phenomena for Bernoulli's free boundary problem

Schedule: July 6 15:30-16:00 Room 301

Michiaki Onodera

Institute of Science Tokyo, Japan

Abstract:

Bernoulli's free boundary problem is an overdetermined boundary value problem in which one seeks an annular domain with a fixed exterior boundary and an interior free boundary, such that the associated capacitary potential also satisfies a prescribed Neumann boundary condition on the free boundary. I will talk about recent developments regarding to a conjecture of Flucher and Rumpf that asserts the existence of a family of free boundaries concentrating at non-degenerate local minima of the Robin function.

Symmetry results in Heisenberg group, Carnot group and Grushin spaces

Schedule: July 6 18:00-18:30 Room 301

Jyotshana Prajapat

University of Mumbai, India

Co-Author(s): Anoop S. Varghese

Abstract:

I will present some of the recent results related to symmetry of solutions of integral equations in the Heisenberg group and Carnot group using the moving plane method with application to the CR Yamabe problem. I will also discuss related progress for the Grushin space.

Some results about the capillary overdetermined problem

Schedule: July 6 15:00-15:30 Room 301

Pieralberto Sicbaldi

Universidad de Granada, Spain

Co-Author(s): Yuanyuan Lian

Abstract:

In this talk we will discuss some results for bounded positive solutions of the capillary overdetermined problem:

$$\left\{ \operatorname{div} \left(\frac{\nabla u}{\sqrt{1+|\nabla u|^2}} \right) + f(u) = 0 \quad \text{in } \Omega \subset \mathbb{R}^n, \quad u = 0 \quad \text{on } \partial\Omega, \quad \partial_\nu u = \text{const.} \quad \text{on } \partial\Omega. \right.$$

In particular, we will show rigidity for some class of domains Ω , including some gradient estimates, and existence of bifurcation for other classes of domains. These are joint works with Y. Lian.

Asymptotic behavior of least energy solutions to the Finsler Lane-Emden problem with large exponents

Schedule: July 6 17:00-17:30 Room 301

Futoshi Takahashi

Osaka Metropolitan University, Japan

Co-Author(s): Sadaf Habibi

Abstract:

In this talk we are concerned with the least energy solutions to the Finsler Lane-Emden problem with large exponent p in the nonlinearity on an N dimensional bounded domain. We prove that the least energy solution is bounded from above and below independent of p large. Precise asymptotic behaviors of energy and mass are obtained. We also obtain the asymptotic behavior of the sup-norm of the least energy solutions as p gets large. Furthermore, we show some concentration phenomena for the scaled functions and prove that the single-point blowup cannot occur on the boundary of the domain. This talk is based on the joint work with Sadaf Habibi (DCDS, 42, no.10 (2022)).

Special Session 66 : Geometric insights in Partial Differential Equations: advances and challenges

Organizer(s): Luca Vilasi , Giovanni Molica Bisci , Vicentiu Radulescu

Introduction: Partial Differential Equations (PDEs) play a fundamental role in addressing a wide range of geometric problems, both in pure mathematics and applied sciences. Recent developments have unveiled new connections between geometric structures and PDE techniques, leading to significant advances in the understanding of existence, uniqueness, and qualitative properties of solutions. However, crucial challenges remain, particularly concerning regularity issues, where singularities and lack of smoothness pose significant obstacles in various contexts. This session aims to explore recent breakthroughs in geometric PDEs, highlighting novel methods and open problems while fostering collaboration among researchers working at the intersection of analysis and geometry.

A three population Lotka-Volterra competition model with two populations interacting through an interface

Schedule: July 7 15:00-15:30 Room 301

Pablo Alvarez-Caudevilla

Universidad Carlos III de Madrid, Spain

Co-Author(s): Cristina Brandle, Monica Molina-Becerra, Antonio Suarez

Abstract:

Consider three species competing with each other in the same habitat. One of the species lives in the entire habitat, competing with the other two species, while the other two inhabit two disjoint regions of the habitat. These two populations just interact on a region/interface which acts as a geographical barrier. Under those circumstances we will show how the barrier condition causes a drastic change in species behaviour compared to the classical Lotka-Volterra competitive model.

A critical Kirchhoff type problem in dimension four

Schedule: July 7 15:30-16:00 Room 301

Giovanni Anello

Department MIFT, University of Messina, Italy

Abstract:

We consider the Dirichlet problem on a bounded smooth domain $\Omega \subset \mathbb{R}^4$, with 0-boundary data, for the nonlinear critical Kirchhoff equation
$$-\left(a+b\int_{\Omega} |\nabla u|^2 dx\right) \Delta u = u^3 + \lambda u^{p-1}, \quad u > 0, \quad u|_{\partial\Omega} = 0$$
 where $a, b, \lambda > 0$ and $p \in (1, 4)$. The main feature of this problem is that the critical exponent for the embedding $W_0^{1,2}(\Omega) \hookrightarrow L^m(\Omega)$ and the exponent of the Kirchhoff term involved in the associated energy functional I_λ are both equals to 4. This gives rise to some difficulties in applying variational methods to find solutions. For instance, working with I_λ , it is not clear how to obtain the boundedness of Palais-Smale sequences or the boundedness of minimizing sequences. We present an approach based on an approximation process that allows to obtain precise constraints on the parameters b, λ ensuring the existence of solutions. In particular, we improve previous results where such constraints were not made explicit.

Regularity for (s,p)-harmonic functions

Schedule: July 7 14:00-14:30 Room 301

Verena Bogelein

University of Salzburg, Austria

Co-Author(s): Frank Duzaar, Naian Liao, Giovanni Molica Bisci, and Raffaella Servadei

Abstract:

We report on higher Sobolev and H^s -older regularity results for local weak solutions of the fractional p -Laplace equation of order $s \in (0, 1)$ with $1 < p < \infty$. The relevant estimates are stable when the fractional order s reaches 1, and the known Sobolev regularity estimates for weak solutions of the local p -Laplace equation are recovered. The talk is based on joint work with Frank Duzaar (Salzburg), Naian Liao (Salzburg), Giovanni Molica Bisci (Urbino), and Raffaella Servadei (Urbino).

Species that live in different habitats: How do boundary conditions affect their behavior?

Schedule: July 7 14:30-15:00 Room 301

Cristina Brandle

U. Carlos III de Madrid, Spain

Co-Author(s): Pablo Alvarez-Caudevilla, Mónica Molina-Becerra and Antonio Suárez

Abstract:

In this talk, we will show examples of population models in which two species live in two different regions of the same habitat, separated by a permeable membrane and only come into contact through it. In this context, the membrane acts as a geographical barrier, and the information exchange across it is modeled using the so-called Kedem-Katchalsky conditions. We analyze the existence and uniqueness of positive solutions as a function of the parameters involved in the system.

SYMMETRY CONSTRAINTS AND VARIATIONAL METHODS FOR SCALAR FIELD EQUATIONS ON UNBOUNDED DOMAIN

Schedule: July 7 17:00-17:30 Room 301

Giuseppe G DEVILLANOVA

Politecnico di Bari, Italy

Co-Author(s): Giovanni MOLICA BISCI, Raffaella SERVADEI, Sergio SOLIMINI

Abstract:

We consider nonlinear scalar field equations on unbounded domains, where lack of compactness due to translations prevents the direct application of classical variational methods. This difficulty can be overcome by exploiting symmetry. A key idea is to replace symmetry assumptions with suitable symmetry constraints. Building on the planar framework, we use barycentric-type conditions to control the distribution of mass and prevent concentration at infinity. Within this approach, we develop a variational scheme based on constrained min-max constructions, where the constraints encode higher-order symmetry properties of the associated measures. This allows us to recover compactness at the level of Palais-Smale sequences and to obtain nontrivial solutions without imposing radial symmetry. We then analyze the structure of these symmetry constraints, showing how they can be characterized in terms of higher-order barycenters and how, in the planar case, they lead to optimal configurations concentrated on the vertices of regular polygons. We also discuss their extension to higher dimensions, where new geometric and algebraic features arise. This perspective provides a unified framework yielding existence and multiplicity results beyond the classical or block-radial symmetric setting.

Parabolic PDEs with Dynamic Data under a Bounded Slope Condition

Schedule: July 7 9:00-9:30 Room 301

Frank Duzaar

University of Salzburg, Austria

Co-Author(s): Verena Boegelein, Giulia Treu

Abstract:

We study the Cauchy-Dirichlet problem for a class of nonlinear parabolic equations with time-dependent boundary data and establish the existence of Lipschitz continuous solutions under minimal assumptions. The main novelty is the introduction of a genuinely time-dependent variant of the classical bounded slope condition. In contrast to existing approaches, this condition allows the supporting hyperplanes of the boundary data to vary in time while remaining uniformly bounded. This yields a flexible geometric framework that accommodates non-stationary boundary values and extends previous results beyond the time-independent setting. Our proof is based on a new barrier construction adapted to the parabolic geometry and the time-dependent boundary behavior. This approach provides control up to the boundary and leads to global Lipschitz bounds for solutions. The method is robust and may be applicable to related parabolic problems. This work was carried out in collaboration with Giulia Treu (University of Padova) and Verena Boegelein (University of Salzburg).

Integrability results for solutions to equations of n -Laplacian type

Schedule: July 7 9:30-10:00 Room 301

Luigi D'Onofrio

Universita' di Napoli Parthenope, Italy

Abstract:

There is an increasing interest in finding optimal conditions ensuring regularity of solutions to n -Laplacian type equations, so aims of this talk are: to give a complete picture of recent results of integrability type in different classes of function spaces and under quite general assumptions and to study the optimality of the estimates found in the setting of Orlicz spaces and in the class of rearrangement invariant spaces

Existence and decay for a Grushin problem in $\mathbb{R}^N$ with singular, convective, critical reaction

Schedule: July 7 17:30-18:00 Room 301

Paolo Malanchini

Universita' degli Studi di Milano - Bicocca, Italy

Co-Author(s): Laura Baldelli, Paolo Malanchini and Simone Secchi

Abstract:

We establish an existence result for a problem set in the whole Euclidean space involving the Grushin operator and featuring a critical term perturbed by a singular, convective reaction. Our approach combines variational methods, truncation techniques, and concentration-compactness arguments, together with set-valued analysis and fixed point theory. Additionally, we prove the decay at infinity of solutions in the absence of the convective term. The result is new even in the case where more than one feature between singularity, convectivity and criticality is taken into account. The talk is based on a joint work with Laura Baldelli (Karlsruhe Institute of Technology) and Simone Secchi (Universita' degli Studi di Milano - Bicocca).

Scaling-based existence and multiplicity results for mixed fractional p -Laplacian equations in $\mathbb{R}^N$

Schedule: July 7 16:30-17:00 Room 301

Kanishka Perera

Florida Institute of Technology, USA

Abstract:

We present new existence and multiplicity results for the mixed fractional p -Laplacian equation

$$\mathcal{A}(u) := (-\Delta)_{p_1}^{s_1} u + (-\Delta)_{p_2}^{s_2} u = f(|x|, u)$$

with

$$u \in \mathcal{D}_{\text{rad}}^{s_1, p_1}(\mathbb{R}^N) \cap \mathcal{D}_{\text{rad}}^{s_2, p_2}(\mathbb{R}^N),$$

where $s_i \in (0, 1)$ and $1 < p_i < N/s_i$ for $i = 1, 2$ and f is a Caratheodory function on $[0, \infty) \times \mathbb{R}$ that satisfies a suitable growth condition. Our results are based on certain scaling properties of the operator $\mathcal{A}$ and recently developed variational methods for scaled functionals.

On a weighted Brezis-Nirenberg-type fractional problem with mixed boundary conditions

Schedule: July 7 18:00-18:30 Room 301

Luca Vilasi

University of Messina, Italy

Co-Author(s): Alejandro Ortega, Youjun Wang

Abstract:

We consider an elliptic problem governed by the spectral fractional Laplacian with mixed Dirichlet-Neumann boundary conditions, weighted critical nonlinearities and subcritical perturbations. By using variational arguments we deduce the existence of multiple positive solutions when the weight suitably behaves around its maximum points. In particular, we get different results depending on whether the Dirichlet Sobolev constant is attained or not, Our results extend and improve similar ones obtained in the local case with purely Dirichlet boundary conditions.

Special Session 67 : Modeling, Machine Learning and Data Analysis for Complex Systems and Dynamics

Organizer(s): Pengcheng Xiao , Honghui Zhang , Lixia Duan

Introduction: Many dynamical systems, as examples from small scale neuronal systems and genomic systems in human, to large scale ecosystems of earth that impact climate change, are featured by nonlinear and complex patterns in spatial and temporal dimensions. These phenomena that are represented by massive amount of data, carry significant information and regulate down-stream dynamics. Understanding the mechanisms underlying such events by quantitative modeling represents a mathematical challenge of current interest. Yet all these systems share the similar dynamical system issues in ordinary/partial differential equation such as bifurcation, stability, oscillations, stochastic noise as well as issues in determining hidden model parameters from experimental data sets and computational errors of the models. This special session offers a forum to exchange the state of the art theoretical advances related to this promising area as well as computational tools. It will foster and encourage communication and interaction between researchers in these directions. The common themes include mathematical models, AI and Machine Learning and data analysis, theoretical analysis, computational and statistical methods of dynamical systems and differential equations for the bio-system focused models, as well as applications in brain research. Other applications in complex systems and data sets in science and engineering are also welcome.

Dynamic Modeling and Regulation of Parkinson's Disease Network

Schedule: July 10 8:00-8:30 Room 642

Zilu Cao

Chang'an University, Peoples Rep of China

Co-Author(s): Zilu Cao, Lin Du, Honghui Zhang, Yuzhi Zhao, Zhuan Shen, Lianghui Qu, Zichen Deng

Abstract:

Parkinson's disease (PD) is one of the most common neurodegenerative diseases. Clinical and experimental evidence suggests that, during the progression of PD, neurons within Cortex-basal ganglia-thalamus (CBGT) circuit exhibit the pathological phenomenon such as abnormal beta-band oscillation and excessive synchronization. To understand the influence of electromagnetic induction and the regulatory effect of electromagnetic stimulation in PD, we investigate physiological and pathological states within a CBGT network model. The results show that the magnetic induction plays a dual role: increasing the magnetic coefficient can not only lead physiological firing patterns to transition into pathological intense firing with enhanced beta band power, but also regulate pathological intense firing and transform it back into physiological firing with weak beta-band power. Moreover, external electromagnetic stimulation applied to the globus pallidus externa (GPe) and pyramidal neuron (PY) effectively suppresses intense firing patterns, beta-band power, and abnormal synchronization in STN, indicating a weakening of pathological oscillations. This work not only elucidates the dual regulatory mechanisms of electromagnetic induction on pathological oscillations in PD, but also provides theoretical foundations for developing noninvasive electromagnetic stimulation as a potential therapeutic strategy for PD.

Prescribed performance projective synchronization for unknown complex networks with mismatched dimensions via event-triggered mechanism

Schedule: July 10 8:30-9:00 Room 642

Aili Fan

Northwestern Polytechnical University, Peoples Rep of China

Abstract:

In this article, we mainly address the function matrix projective synchronization (FMPS) problem with prescribed performance (PP) between a drive network (DN) with time-varying uncertain coupling, and its corresponding response network (RN) with mismatched dimensions. A new hybrid adaptive learning law is proposed, which consists of a discrete adaptive law designed for unknown time-varying coupling coefficients, and a continuous adaptive law designed for time-invariant coefficients. The proposed work extends the adaptive synchronization control that is originally applicable only with the constant coupling coefficient to the case where the coefficients are time-varying. To ensure the state trajectories of the RN are projectively synchronized to those of the DN while complying with PP constraints, a PP controller is designed. Meanwhile, to reduce the communication load, the event-triggered communication (ETC) mechanism is implemented. Finally, the effectiveness of the designed.

Time scale governs explosive transitions in two-layer multiplex networks

Schedule: July 10 9:00-9:30 Room 642

Shutong Liu

Shaanxi Normal University, Peoples Rep of China

Co-Author(s): Shutong Liu, Yuchen Miao, Yi Song, Nannan Zhao, Zhongkui Sun

Abstract:

This study investigates the mechanism of explosive oscillation quenching in a two-layer network where oscillators interact with an environmental layer via feedback coupling, with particular focus on how dynamic time scale governs transitions between bistable regimes. It is demonstrated that significant time scale differences induce and enhance explosive nontrivial amplitude death, characterized by prominent hysteresis and emergent bistability between complete synchronization and nontrivial amplitude death. As the time scale parameter varies, the system evolves through multiple dynamical regimes, including semi hysteresis region where amplitude death and nontrivial amplitude death coexist. Furthermore, the work establishes that both the hysteresis associated with explosive death and subsequent multistability regions can be systematically controlled by adjusting the time scale parameter. Moreover, the analysis reveals that strong inter-layer coupling facilitates multistability, while the damping coefficient and intrinsic frequency collectively regulate the accessibility of explosive versus continuous transitions. Theoretical stability boundaries derived through lyapunov analysis show excellent agreement with numerical simulations, validating the proposed mechanisms. This work elucidates the fundamental principles governing explosive oscillations and multistability in multilayer networks, thus providing a new understanding of oscillation control mechanisms, which proves essential for manipulating dynamical behaviors through time scale tuning.

Sparse Discovery of Functional Relationships in Solutions to Systems of Differential Equations

Schedule: July 10 11:30-12:00 Room 642

Nicolae Tarfulea

Purdue University Northwest, USA

Abstract:

In this talk, we introduce a general technique for discovering functional relationships among the components of solutions to initial value problems for systems of differential equations. The approach leverages sparse identification techniques applied to data generated from numerical solutions of the given initial value problem. The central assumption is that only a small number of terms govern the interactions among components, leading to mathematical relations that are sparse within the broader space of possible functions. We demonstrate the effectiveness and versatility of the method through a series of illustrative applications.

On a Splitting Method for Solving of the Nonlinear Schrodinger Equation and Its Generalization to the Manakov System

Schedule: July 10 10:30-11:00 Room 642

Michail Todorov

Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria

Co-Author(s): Meglena Lazarova

Abstract:

In this paper we aim to demonstrate that the splitting by physical factors is applicable and can be efficient for solving of the nonlinear Schrodinger equation. Both the linear and nonlinear parts are treated by the Runge-Kutta method, the nonlinear term, however, is linearised by the so-called inner iteration. The method can be expanded and relatively easily applied for 2+1d Schroedinger equation by adding a coordinate splitting of the spatial coordinates as well as to the Manakov system. Then the procedure should be applied for each equation in the system. The conducted numerical simulations and their results are reliable and give good predictions for the material quantities and dynamics of the light. They give very good comparison with the previous papers of the authors got in another methods.

Improving The PERT Activity Duration Estimation

Schedule: July 10 11:00-11:30 Room 642

Xiaohui Wang

University of Texas Rio Grande Valley, USA

Co-Author(s): Gifty Duah and Xiaohui Wang

Abstract:

Accurate estimation of activity durations is fundamental in project scheduling, industrial planning, and service systems where uncertainty and variability affect decision-making. Traditional Program Evaluation and Review Technique (PERT) models rely on three subjective time estimates - optimistic, most likely, and pessimistic - to approximate expected activity duration. However, empirical activity durations are frequently skewed, limiting the accuracy of the classical PERT formulation. Existing literature studied approaches utilizing normal or lognormal approximations that worked for data with either symmetric or the right skewed underlying activity distributions, but their applications are limited for moderate or heavily left skewed data. Abdel-Raheem et al. (2018) introduced refinements with triangular distributions due to its comprehensibility to the project planner and proposed a framework allowing the determination of the contract time using deterministic and probabilistic scheduling techniques. This approach has its own limitations. To overcome these limitations and enable broader applications, this study proposes an enhanced method for activity duration estimation using maximum likelihood estimation applied to lognormal distributions. Using empirical production-rate data, we evaluate estimation accuracy and demonstrate improvements over existing methods.

Computational Analysis of Stress-Induced Glucocorticoid Effects on Cognitive Processing

Schedule: July 10 14:00-14:30 Room 642

Pengcheng Xiao

Kennesaw State University, USA

Abstract:

The focus of this study is to investigate the effects of different stress levels on cognitive outcomes. Emerging evidence has shown that stress-induced release of glucocorticoids acts on glutamate neurotransmission and consequently influences the functionality of cognitive processing. By incorporating the Hypothalamic-pituitary-adrenal (HPA) axis and neuron models, we study the plasticity regulation outcomes based on two types of stress: stress with regular object and stress object with PTSD. The results can help to understand the dynamical mechanism between the glucocorticoids releasing and the neuron plasticity changes due to different stress levels.

Intelligent Modulation of Brain Disorders Driven by Data and Models

Schedule: July 10 14:30-15:00 Room 642

HONGHUI ZHANG

Northwestern Polytechnical University, Peoples Rep of China

Co-Author(s): youyou Si, Hengxi Zhang, Ruimin Dan

Abstract:

Based on the whole-brain structural and functional networks, and driven by the dual impetus of models and electroencephalographic data, we design a brain-inspired neural network algorithm and propose targeted theoretical intervention schemes for the detection, prediction, diagnostic analysis and neuromodulatory therapy of brain disorders such as epilepsy, Parkinson's disease and autism, respectively. We also develop cross-patient optimized algorithms and schemes to improve accuracy, reduce energy consumption and enhance generalization ability.

Unraveling Epileptic Dynamics via Neurovascular Coupling: A Tripartite Neuro-Astrocytic-Arteriolar Computational Framework

Schedule: July 10 13:30-14:00 Room 642

Liyuan Zhang

Beijing University of Technology, Peoples Rep of China

Co-Author(s): Liyuan Zhang, Mingai Li, Youjun Liu

Abstract:

Epilepsy is a common neurological disorder associated with dysfunction in neurovascular coupling (NVC). To advance beyond current limited models, this study develops a mathematical model integrating neurons, astrocytes, and arterioles to investigate epileptic mechanisms. Neuronal dynamics are described by an extended Hodgkin Huxley model, while arteriole diameter changes are simulated via a filament sliding mechanism in smooth muscle. The model incorporates key ion channels (calcium activated potassium channel, inwardly rectifying potassium channel) and signaling molecules (oxygen, calcium, nitric oxide) to simulate neuro-hemodynamic responses. Results show six transitional neuronal firing patterns under external stimulation, with bifurcation analyses explaining low voltage fast oscillations, tonic spiking, and bursting. Simulations confirm that neuronal activation triggers astrocytic calcium waves, leading to vasodilator release and arteriole dilation. Additionally, asymptotic ionic concentration changes during ischemia, hypoxia, and astrocytic dysfunction are characterized. This multi-pathway NVC framework offers a more realistic and comprehensive perspective on epileptic pathology.

Special Session 68 : Optimal control theory and applications

Organizer(s): Ellina Grigorieva , Monica Motta , Carlo Mariconda

Introduction: This session explores some of the latest advancements in the theory of optimal control and its diverse applications across engineering, robotics, life sciences, medicine and economics. Optimal control theory is a powerful mathematical framework used to determine control policies that optimize a desired performance criterion for dynamical systems—whether finite or infinite dimensional, deterministic or stochastic. This session seeks to present innovative contributions that advance the understanding and application of optimal control theory, particularly for nonlinear systems.

Optimal boundary control for the Cahn-Hilliard-Navier-Stokes Equations

Schedule: July 7 18:00-18:30 Room 311

Manika Bag

Indian Institute of Science Education and Research, Thiruvananthapuram, India

Co-Author(s): Manika Bag, Tania Biswas, Sheetal Dharmatti

Abstract:

We present an optimal boundary control problem for a Cahn-Hilliard-Navier-Stokes (CHNS) system in a two-dimensional bounded domain. The CHNS system consists of a Navier-Stokes equation governing the fluid velocity field coupled with a convective Cahn-Hilliard equation for the relative concentration of the fluid. An optimal control problem is formulated as the minimization of a cost functional subject to the controlled CHNS system where the control acts on the boundary of the Navier-Stokes equations. We first study that there exists an optimal boundary control. Then we establish that the control-to-state operator is Frechet differentiable and derive first order necessary optimality conditions in terms of a variational inequality involving the adjoint system.

Necessary conditions of optimality for dynamic optimization problems involving parameters

Schedule: July 7 14:30-15:00 Room 311

Piernicola Bettiol

University of Brest, France

Abstract:

Optimal control problems with parameters provide a natural modelling framework for a wide range of applications, including aerospace engineering, machine learning, and biological systems. Depending on the underlying model and objectives, different performance criteria may be adopted. For instance, in some circumstances, average-cost formulations offer an alternative to classical minimax or robust optimization. Such problems may exhibit even multi-level structures, for example when an optimal control problem is coupled with a nonlinear programming problem arising from parameter optimization or estimation. In this talk, we introduce classes of parameter-dependent optimal control problems in which unknown parameters appear in the system dynamics, the cost function, endpoint constraints, and possibly even in the state constraints. For the different cost criteria under consideration, we derive and discuss the corresponding necessary conditions of optimality.

Set-valued Lie brackets and non-smooth controllability

Schedule: July 7 17:00-17:30 Room 311

Rampazzo Franco

University of Padova, Italy

Co-Author(s): Franco Rampazzo, Ermal Feleqi, Rohit Gupta

Abstract:

Small time local controllability for a control system of ODEs consists in the fact that, for every sufficiently small $t > 0$, the points reached at a time $s \leq t$ by the trajectories of the system starting from a point x_* form a full neighborhood of x_* . In the case of a dynamics which is (nonlinear but) linear in the controls, the celebrated Rashevskii-Chow's theorem states that the so-called full rank-condition--namely the fact that iterated Lie brackets of the involved vector fields generate the whole tangent space-- is sufficient for small time local controllability. Rashevskii-Chow's theorem is classically obtained under hypotheses of C^∞ regularity. In this talk I will illustrate how this result (and other similar ones) can be extended by means of a notion of set-valued Lie bracket up to the point that the highest order brackets involved in the full rank condition are just almost everywhere defined, bounded, maps. There are several applications of such controllability results, e.g. in the study of subelliptic pde's and of Carnot-Carathéodory spaces. In particular, the presented result might represent a basis for a highly non-smooth subRiemannian geometry.

A Two-Stage Optimal Control Problem in the Lotka-Volterra Competition Model for Cancer Treatment

Schedule: July 7 15:00-15:30 Room 311

Ellina Grigorieva

Texas Woman's University, USA

Co-Author(s): Evgenii Khailov

Abstract:

Traditional continuous hormonal therapy for metastatic prostate cancer is often ineffective because it unintentionally favors drug-resistant cells by eliminating their drug-sensitive competitors. To address this issue, intermittent therapy, which involves cyclic periods of drug dosing and withdrawal, is used. This approach preserves the population of drug-sensitive cells, which, by competing for shared resources, suppress the proliferation of resistant strains. In this study, we formulate and analyze an optimal control problem using the Lotka-Volterra competition model. The model includes a control function for regulating transitions between therapeutic stages to determine an optimal solution that reproduces the effectiveness of intermittent regimens in balancing cancer cell dynamics. Optimal prostate cancer treatment protocols are derived and their application in real-world clinical practice is discussed.

Young differential inclusions and their properties

Schedule: July 7 15:30-16:00 Room 311

Mariusz Michta

Institute of Mathematics, University of Zielona Gora, Poland

Co-Author(s): Mariusz Michta

Abstract:

In the talk, we present new types of differential inclusions with a set-valued Young integral, which generalize a single-valued Young differential equation. In the single-valued case, the Young integral has been used in a wide range of applications. In particular, one can consider stochastic equations with respect to non-semimartingale integrators, such as the Mandelbrot fractional Brownian motion, which has H^{α} -continuous sample paths. Thus, it seems reasonable to investigate differential inclusions driven by such a new type of integral. In the presentation, we shall establish the main properties of solution sets of Young differential inclusions. In particular, solutions to an abstract optimization problem related to the inclusion will be presented. References: 1. M. Michta, J. Motyl, Selection properties and set-valued Young integrals of set-valued functions, *Results Math.* 75, 164 (2020). 2. M. Michta, J. Motyl, Set-valued functions of bounded generalized variation and set-valued Young integrals, *J. Theor. Probab.* 35 (2022), 528-549. 3. M. Michta, J. Motyl, Solution sets for Young differential inclusions, *Qual. Theory Dyn. Syst.* 22, 132 (2023). 4. M. Michta, J. Motyl, Properties of set-valued Young integrals and Young differential inclusions generated by sets of H^{α} -continuous functions, *Nonlinear Differ. Equ. Appl.* 31, article no 70 (2024).

Minimizers that are not impulsive minimizers and higher order abnormality

Schedule: July 7 16:30-17:00 Room 311

Monica Motta

Department of Mathematics, University of Padova, Italy

Co-Author(s): Michele Palladino and Franco Rampazzo

Abstract:

This talk addresses two related problems in optimal control. The first investigation consists of compatibility issues between two classical approaches to deriving necessary conditions for optimal control problems with a final target: the set-separation approach and penalization techniques. These methods generally lead to non-equivalent conditions, mainly due to their reliance on different notions of tangency at the target. We address this issue by considering Quasi Differential Quotient (QDQ) approximating cones (which are fit for the set-separation approach) and identifying conditions under which the Clarke tangent cone (which is a typical tool within penalization techniques) is also a QDQ approximating cone. In particular, we show that this property holds under suitable local invariance assumptions or when the target coincides locally with an r -prox regular set. Then, we apply this compatibility result to the study of infimum-gap phenomena in optimal control problems with unbounded controls and impulsive extensions. In particular, we establish a connection between the occurrence of infimum gaps for strict-sense minimizers and abnormality in a higher-order Maximum Principle involving Lie brackets. While the abnormality-gap correspondence beyond first-order conditions has been already established for impulsive minimizers, the utilization of the above compatibility issues allow us to extend this correspondence to strict-sense minimizers.

Superlinearity and Monotonicity in Electrical Resistance Tomography

Schedule: July 7 14:00-14:30 Room 311

Teresa Scarinci

teresa scarinci, Italy

Co-Author(s): A. Corbo, A. Tamburrino

Abstract:

The talk describes a mathematical method for solving the Calderon problem, i.e., determining the interior of a material from boundary data consisting of the Dirichlet-to-Neumann (DtN) map in electrical resistance tomography (elliptic PDE). After introducing the DtN operator, we investigate its properties, including superlinearity and monotonicity. These properties are then used to create a fast imaging method formulated as a proper constrained optimisation problem.

Self-Dual Approximations in Fully Convex Control Problems

Schedule: July 7 17:30-18:00 Room 311

Peter Wolenski

Louisiana State University, USA

Abstract:

We present an approximation technique to Fully Convex Bolza problems using Goebel's self-dualizing envelope that preserves the duality structure.

Special Session 69 : Mathematical Models and Analysis of (Partial) Differential Equations in the Applied Sciences

Organizer(s): Alain Miranville , Andreas Chatziafratis , Georgia Karali

Introduction: Differential equations, both deterministic and stochastic, play a fundamental role in modeling complex phenomena across applied sciences such as solid and fluid mechanics, materials science, biological systems and mathematical finance. Topics of interest include, but are not limited to, rigorous analysis, calculus of variations, reaction-diffusion equations, dynamical systems, free-boundary problems and related models and methods. The session also aims to explore emerging trends as well as challenges in partial differential equations which arise in these fields, and provide new directions for future investigation.

Nonlinear gradient effects in viscoelasticity

Schedule: July 9 8:30-9:00 Room 618

Aseel AlNajjar

King Abdullah University of Science and Technology(KAUST), Saudi Arabia

Abstract:

We consider a system of strain-gradient viscoelasticity arising in phase transition models, with a particular focus on nonlinear dispersive effects. In the onedimensional case, we prove the existence of weak solutions under minimal assumptions, highlighting the role of nonlinear strain-gradient terms in the analysis. In the case of constant dispersion and in the multi-dimensional case, we prove global existence results and investigate the zero dispersion limit, including a rate of convergence in two space dimensions. We conclude by discussing some of the main challenges that arise in the presence of physical boundaries.

Nonexistence of multi-dimensional solitary waves for the Euler-Poisson system

Schedule: July 9 17:00-17:30 Room 618

Junsik Bae

Kyungpook National University, Korea

Co-Author(s): Daisuke Kawagoe

Abstract:

We study the nonexistence of multi-dimensional solitary waves for the Euler-Poisson system governing ion dynamics. It is well-known that the one-dimensional Euler-Poisson system has solitary waves that travel faster than the ion-sound speed. In contrast, we show that the two-dimensional and three-dimensional models do not admit nontrivial irrotational spatially localized traveling waves for any traveling velocity and for general pressure laws. Our results provide theoretical evidence for the stability of line solitary waves in multi-dimensional Euler-Poisson flows. We derive some Pohozaev type identities associated with the energy and density integrals. This approach is extended to prove the nonexistence of irrotational multi-dimensional solitary waves for the two-species Euler-Poisson system for ions and electrons.

Analytical and Computational Methods for Bifurcation Analysis of Collapsing Solutions to Nonlinear Dispersive PDEs

Schedule: July 9 8:00-8:30 Room 618

Efstathios Charalampidis

San Diego State University, USA

Abstract:

In this talk, the finite-time blow-up in nonlinear dispersive PDEs will be discussed as a bifurcation problem. First, we will present a universal framework for the identification of self-similar waveforms as stationary solutions in a frame that co-explodes with the solution. This will allow us to perform a spectral analysis of these solutions in the co-exploding frame in order to infer their stability. As prototypical examples, we will consider the 1D Nonlinear Schroedinger (NLS) equation with power-law nonlinearity and generalized Korteweg-de Vries (gKdV) model. Self-similar collapsing branches emanate from the solitary branch at critical nonlinearity exponent therein. However, their stability analysis will reveal the emergence of unstable modes which in turn are intimately connected with symmetries of the systems in the original frame. We will show that these modes do not correspond to true instabilities but rather to neutral eigen-directions. Numerical results both at the existence and stability will be compared with normal forms and WKB results where an excellent agreement will be observed between the two. Then, time-permitting, we will depart from 1D settings and focus our considerations on the 2D NLS model with power-law nonlinearity. The accurate computation of states and their stability requires to use alternative techniques. Indeed, we will present a computational framework that have been developed in the open source software FreeFEM that combines domain-decomposition methods and mesh adaptivity tools. Novel results will be discussed together with the performance of the numerical codes.

Mathematical model for tumor growth and lactate kinetics in glioma

Schedule: July 9 14:30-15:00 Room 618

Laurence L. Cherfils

La Rochelle University, France

Abstract:

Gliomas are widespread and invasive brain tumors. Except for grade I gliomas, which can be cured after complete surgical resection, the prognosis remains poor for grade II to IV gliomas, despite radiotherapy and chemotherapy treatments. Recent studies have shown that lactate plays an important role in tumor growth, and new therapeutic strategies targeting lactate metabolism have emerged. In this talk, I will present a mathematical model (in the form of partial differential equations) that describe both the temporal evolution of tumor cell density and lactate kinetics within the tumor. Two therapies are incorporated into the model: a chemotherapy treatment and a therapy specifically targeting lactate production or transport. These treatments are considered as control functions, and we seek an optimal therapeutic strategy, i.e., patient-specific dosages that are as low as possible to minimize side effects without reducing treatment efficacy. I will present results related to the mathematical analysis of these models and propose several numerical simulations to illustrate our findings.

A Coupled Surface Diffusion and Mean Curvature Flow problem - Steady States and Stability

Schedule: July 9 18:00-18:30 Room 618

Daniel Goldberg

Technion - Israel Institute of Technology, Israel

Co-Author(s): Daniel Goldberg and Amy Novick-Cohen

Abstract:

Patterned thin gold lines when undergoing solid-state dewetting break up into linear grain sections interspersed with occasionally larger "abacus" particles. We model this system using coupled geometric flows, where the exterior surfaces of the grains evolve via Surface Diffusion $V = -\Delta \Gamma(t)H$ and the internal grain boundaries evolve via Mean Curvature Flow $V = AH$. In this talk we first motivate the problem using these experimental observations. Next, we describe the steady states for this mixed-order system. By assuming axi-symmetry, we can systematically construct composite equilibria by piecing together Delaunay surfaces --- specifically, combining unduloidal, cylindrical and spherical exterior surfaces partitioned by planar or catenoidal internal grain boundaries. We then introduce a stability analysis by first linearising the coupled (nonlinear) problem about these composite steady states, deriving a Jacobi operator whose strict positivity implies asymptotic stability of the linearised problem. Using this approach and building upon the classical Rayleigh stability criteria, we obtain stability predictions for steady-state configurations consisting of near-cylindrical and near-spherical grains meeting at a single planar grain boundary.

Localization of Self-Similar Solutions in Diffusion-Relaxation Systems

Schedule: July 9 18:30-19:00 Room 618

Hoyoun Kim

King Abdullah University of Science and Technology (KAUST), Korea

Abstract:

In this talk, we construct localizing solutions for diffusion-relaxation systems by exploiting their self-similar structure. Diffusion-relaxation models arise in a wide range of applications, from shear-induced motion to biological chemotaxis, and exhibit equilibration and localization depending on parameter regimes. We extend the self-similar formulation to multi-dimensional domains and analyze the resulting asymptotic behavior of solutions. Using geometric singular perturbation theory and the Poincaré-Bendixson lemma on a perturbed invariant manifold, we establish the existence of localized self-similar solutions.

Constructing Steady States Using Delaunay Surfaces

Schedule: July 9 14:00-14:30 Room 618

Amy Novick-Cohen

Technion - Israel Institute of Technology, Israel

Co-Author(s): D. Goldberg, K. Golubkov, Y. Vaknin, A. Zigelman

Abstract:

Delaunay surfaces were introduced by Delaunay in 1841, and the motions known as mean curvature flow and surface diffusion were introduced by Mullins in 1956 and 1957, respectively, in modelling materials science processes. Quite recently has it been noted that the Delaunay surfaces may be successfully combined to describe various materials science phenomena, such as hillock and hole formation, and line grating structures. We review some of these constructions and their implications, indicating open questions and future directions. [1] K. Golubkov, A. Novick-Cohen, Y. Vaknin, Coupled surface diffusion and mean curvature motion: an axisymmetric system with two grains and a hole. *Quart. Appl. Math.* 83 (2025) 97-134. [2] A. Zigelman & A. Novick-Cohen, Critical effective radius for holes in thin films: energetic and dynamic considerations. *J. Appl. Phys.* 134 (2023) 135302. [3] D. Goldberg & A. Novick-Cohen, Rayleigh type stability criteria for certain coupled surface diffusion and mean curvature flows, in preparation.

Convergence to self-similarity for the additive Smoluchowski coagulation equation with source

Schedule: July 9 13:30-14:00 Room 618

Robert Pego

Carnegie Mellon University, USA

Abstract:

We study long-time behavior of cluster-size distributions for the Smoluchowski coagulation equation with time-dependent injection of mass, in the critical case when the rate kernel is additive in cluster sizes. Scaled by an expected cluster size, solutions converge to the same self-similar profile for a great variety of injection schedules, corresponding to mass growth histories that are constant, power law, exponential, and double exponential, e.g. Key ingredients in the analysis are: an improved continuity theorem for Bernstein transforms (aka Laplace exponents), and scaling analysis of characteristics for the PDE that transforms satisfy.

Sharp front asymptotics in cascading Fisher KPP systems and multitype Branching Brownian Motion

Schedule: July 9 15:00-15:30 Room 618

Alexandra Stavrianidi

University of Munster, Germany

Abstract:

The Fisher KPP equation is closely connected to Branching Brownian Motion, through the McKean representation, its solution describes the distribution of the maximal particle in the branching system. In this talk, I will discuss the long time behavior of coupled Fisher KPP reaction diffusion systems with interacting components associated with multitype Branching Brownian Motion. For a two component system, we show that the interaction modifies the classical Bramson logarithmic delay. Our PDE approach confirms previously known probabilistic results and extends them to general Fisher KPP nonlinearities. More generally, for cascading systems with k components, we establish sharp front asymptotics and convergence to the minimal speed traveling wave, providing a PDE proof of the conjectured asymptotics for the median position of the maximal particle in a cascading Branching Brownian Motion.

Mullins' nonlinear grooving solutions

Schedule: July 9 9:00-9:30 Room 618

Rawan Tarabeh

Technion - Israel Institute of Technology, Israel

Co-Author(s): Rawan Tarabeh

Abstract:

The problem of thermal grooving was first proposed by Mullins in 1957. Mullins considered the morphological evolution of thin solid surfaces, namely solid films, and focused primarily on the exterior surface motion with surface diffusion as the dominant mass transport process. By assuming a small slope approximation, the problem can be reduced to a linear surface diffusion problem. Mullins showed that there exist self-similar solutions for the linearized problem. In the present study, we prove the existence and uniqueness of a self-similar solution for the original nonlinear Mullins' problem for sufficiently small values of the contact angle β . We do so by studying a reduced linear ODE system, which allows us to understand the asymptotic behavior of the solutions for the corresponding linear homogeneous operator, and then we prove existence of a unique solution to the nonlinear problem in closed form by iterations in an appropriate Banach space. Our methodology should be possible to implement in other problems of interest, such as the Wang's nonlinear problem for surface evolution of wedges.

Nonlinear waves in metamaterials: from the left-handed regime to the frequency band gaps

Schedule: July 9 16:30-17:00 Room 618

Nikolaos L. Tsitsas

Aristotle University of Thessaloniki, Greece

Abstract:

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Conservation Laws Constrained by Linear PDEs

Schedule: July 9 9:30-10:00 Room 618

Andreas Vikelis

University of Vienna, Austria

Abstract:

Linear PDE constraints, expressed through constant rank operators, arise naturally in continuum mechanics and impose a specific analytical structure on the admissible states of conservation laws. This structure leads to a natural notion of convexity, acting precisely along the directions in which the operator loses ellipticity. In the talk, it will be discussed how the convexity determined by the PDE constraint, together with the constraint itself, yields robust stability and uniqueness properties for the associated general systems of conservation laws.

Stochastic homogenization of a droplet model in liquid-liquid phase transitions

Schedule: July 9 17:30-18:00 Room 618

Konstantinos Zemas

University of Bonn, Germany

Co-Author(s): Adriana Garroni, Caterina Zeppieri

Abstract:

We rigorously derive, by means of Γ -convergence, a sharp-interface model for the coexistence of different liquid phases in a domain with a random distribution of droplets, in which a certain phase is prescribed. Starting from a diffuse-interface model of Modica-Mortola type, we show that under very broad assumptions on the droplet geometry (modelled probabilistically via a stationary marked point process), and at a critical scaling, a stochastic bulk term of capacitary type attributed to each other phase appears in the limit. This is joint work with Adriana Garroni (Sapienza University of Rome) and Caterina Zeppieri (University of Muenster)

On the density of the supremum of nonlinear SPDEs

Schedule: July 9 15:30-16:00 Room 618

Pavlos Zoubouloulou

University of Muenster, Germany

Abstract:

We study the one-dimensional stochastic partial differential equation
$$\frac{\partial u}{\partial t}(t,x) = -\kappa \frac{\partial^4 u}{\partial x^4}(t,x) + \rho \frac{\partial^2 u}{\partial x^2}(t,x) + b(u(t,x)) + \sigma(u(t,x)) \dot{W}(t,x),$$
 posed on a bounded spatial domain, where u is understood in the random field sense. Depending on the value of κ , this equation includes the nonlinear stochastic heat equation with Dirichlet or Neumann boundary conditions, as well as the linearized stochastic Cahn-Hilliard equation with Neumann boundary conditions. We prove that the supremum of the solution admits a density with respect to the Lebesgue measure. Our approach is based on Malliavin calculus, and in particular on the version of the Bouleau--Hirsch criterion for suprema developed by Nualart and Vives. One of the main difficulties lies in the analysis of the argmax set of the solution and in showing that the Malliavin derivative is almost surely nondegenerate on this set. As part of our arguments, we establish Hölder continuity properties for the Malliavin derivative of the solution as an L^2 -valued process in the regimes considered in this work.

Special Session 70 : Progress and Challenges in Nonlocal and Nonhomogeneous PDEs

Organizer(s): Anouar Bahrouni , Ariel Salort

Introduction: The remarkable development of homogeneous partial differential equations (PDEs) is largely driven by their ability to model various phenomena and materials in applied sciences. However, for certain nonhomogeneous materials, such as electrorheological fluids, classical homogeneous PDEs are insufficient. This has led to the study of Orlicz-Sobolev and Musielak-Sobolev spaces and their associated PDEs, which have been extensively investigated. More recently, researchers have introduced fractional versions of Orlicz-Sobolev and Musielak-Sobolev spaces, along with their applications to PDEs. This study is still in progress, and many open problems remain. Given these recent advancements, this session aims to bring together leading researchers in the field to present their latest findings and explore future directions in nonlocal and nonhomogeneous PDEs.

Fractional Orlicz-Sobolev Spaces: Embeddings & Continuity properties

Schedule: July 9 8:30-9:00 Room 421

Angela Alberico

Italian National Research Council - Institute for Applied Calculus (Napoli), Italy

Co-Author(s): Lubos Pick and Lenka Slavikova

Abstract:

The optimal target space is exhibited for embeddings of fractional-order Orlicz-Sobolev spaces. Both the subcritical and the supercritical regimes are considered. In the former case, the smallest possible Orlicz target space is detected. In the latter, the relevant Orlicz-Sobolev spaces are shown to be embedded into the space of bounded continuous functions in $\mathbb{R}^n$. Moreover, their optimal modulus of continuity is exhibited. These results are the subject of a series of joint papers with Andrea Cianchi, Luboš Pick and Lenka Slavíková.

Regularity results and maximum principles for quasilinear operators of mixed local-nonlocal type

Schedule: July 7 16:30-17:00 Room 421

Carlo Alberto Antonini

University of Milan (UniMi), Italy

Abstract:

In this talk, we will deal with mixed local-nonlocal quasilinear operators, modeled upon the sum of a p -Laplacian and a fractional (s, q) -Laplace operator, i.e., $-\Delta_p u + (-\Delta_q)^s u$. We will review some recent results concerning local and global regularity of their solutions, and we will address the validity of maximum principles and Hopf Lemma for such operators. Based on a series of joint works with M. Cozzi and P. Baroni.

Irregular double-phase evolution problem: Existence and Global regularity

Schedule: July 7 17:30-18:00 Room 421

Rakesh Arora

Indian Institute of Technology, Varanasi, India

Co-Author(s): Sergey Shmarev

Abstract:

This talk presents the existence and regularity results of the homogeneous Dirichlet problem involving the double-phase operator with variable exponents, non-differentiable modulating coefficients and the free term f . We establish the existence of a strong solution, which preserves initial temporal integrability, gains global higher integrability and improves second-order regularity.

DOUBLE PHASE PROBLEMS WITH EXPONENTS DEPENDING ON SOLUTIONS AND THEIR GRADIENTS

Schedule: July 9 14:30-15:00 Room 421

Anouar Bahrouni

University of Monastir, Tunisia

Co-Author(s): Ala Eddine Bahrouni and Hlel Missaoui

Abstract:

In this talk,, we introduce two novel classes of quasilinear elliptic equations, each driven by the double phase operator with variable exponents. The first class features a new double phase equation where exponents depend on the gradient of the solution. In the second category, the treatment of exponents is dependent on the solution itself. This class differs from the first one due to the unavailability of suitable Musielak-Orlicz Sobolev spaces. For this reason, we employ a perturbation argument that leads to the classical double phase class.

ON UNBOUNDED SOLUTIONS OF ERGODIC PROBLEMS FOR NON-LOCAL HAMILTON-JACOBI EQUATIONS

Schedule: July 7 17:00-17:30 Room 421

Cristina Brandle

U. Carlos III de Madrid, Spain

Co-Author(s): Emmanuel Chasseigne

Abstract:

We study an ergodic problem associated to a non-local Hamilton-Jacobi equation defined on the whole space $\lambda - \mathcal{L}[u](x) + |Du(x)|^m = f(x)$ and determine whether (unbounded) solutions exist or not. We prove that there is a threshold growth of the function f , that separates existence and non-existence of solutions, a phenomenon that does not appear in the local version of the problem. Moreover, we show that there exists a critical ergodic constant, λ_* , such that the ergodic problem has solutions for $\lambda \leq \lambda_*$ and such that the only solution bounded from below, which is unique up to an additive constant, is the one associated to λ_* .

On the weak Harnack inequality for a generalized Orlicz De Giorgi class

Schedule: July 9 9:00-9:30 Room 421

Simone ciani

University of Bologna Alma Mater, Italy

Co-Author(s): Eurica Henriques, Igor I. Skrypnik

Abstract:

We introduce a generalization of De Giorgi classes with Orlicz growth. The aim is twofold: on the one hand, to encompass a broader class of functionals and equations; on the other hand, to provide a definition based on a simple energy inequality that does not rely on an underlying functional, but rather on the intrinsic scaling between radii and levels. For these classes, we establish a Weak Harnack inequality, thereby unifying its validity across non-uniformly elliptic equations, double-phase and degenerate double-phase functionals, as well as functionals with variable exponents.

No pain, no gain on critical logarithmic double phase equations

Schedule: July 9 8:00-8:30 Room 421

Alessio Fiscella

Universidade Estadual de Campinas, Brazil

Abstract:

In this talk, we discuss about double phase equations set in $\mathbb{R}^N$ involving critical Sobolev terms and logarithmic perturbations. By variational methods, we provide different existence results for our equations. The main difficulties arise from the presence of the logarithmic perturbation, which is sign-changing, combined with a double lack of compactness, due to the free action of translation group in $\mathbb{R}^N$ and the critical Sobolev nonlinearity. Furthermore, we have to deal with the Luxemburg type norm of the solution space, which complicates even the study of geometry for the energy functional. Our results, contained in <https://doi.org/10.1016/j.jmaa.2025.129311> and in <https://doi.org/10.1007/s00030-025-01172-1>, are new even in the classical p -Laplacian case.

Wiener criterion for nonlocal and nonhomogeneous equations

Schedule: July 7 18:30-19:00 Room 421

Minhyun Kim

Hanyang University, Korea

Co-Author(s): Ki-Ahm Lee, Se-Chan Lee

Abstract:

In this talk, we present the Wiener criterion for nonlocal equations with Orlicz growth, which provides a necessary and sufficient condition for boundary points to be regular. Our approach relies on the fine analysis of superharmonic functions in view of nonlocal nonlinear potential theory. Especially, the Wolff potential estimates play a fundamental role.

On polyharmonic double phase problems

Schedule: July 9 13:30-14:00 Room 421

Tuhina Mukherjee

Indian Institute of Technology Jodhpur, India

Co-Author(s): Ashutosh Dixit

Abstract:

This talk shall be on study of higher-order doubly critical elliptic problems with weights, driven by a polyharmonic double phase operator. Precisely, problems of the type
$$\begin{cases} \mathcal{L}_{p,q}^m(u) = f(x,u) & \text{in } \Omega \\ u = \nabla u \cdot \nabla^{m-1} u = 0 & \text{on } \partial\Omega \end{cases}$$
 where $\Omega \subset \mathbb{R}^N$ with $N \geq 2$ is a smooth bounded domain with Lipschitz boundary $\partial\Omega$, $m \in \mathbb{N}$, $1 < p < q < \frac{N}{m}$ with $(N-1)q \leq Np$, the nonlinear term $f: \Omega \times \mathbb{R} \rightarrow \mathbb{R}$ is Caratheodary function, which has doubly critical growth, and $\mathcal{L}_{p,q}^m$ represents a polyharmonic double phase operator. I shall present suitable Musielak--Orlicz--Sobolev framework to study such problems, through application of variational methods. The existence of weak solutions can be derived by establishing a compactness result within these spaces and in addition, the nonexistence results can also be derived under appropriate assumptions by establishing a Pohozaev-type identity for higher-order derivatives. The overall approach is an extension of classical techniques to capture the intricate features of the double phase operator for higher-order derivatives, and shall address the difficulties arising from critical nonlinearities, while also overcoming the non closed feature of truncations in higher order Sobolev spaces.

Periodically perforated energies in the nonlocal setting

Schedule: July 7 18:00-18:30 Room 421

Giampiero Palatucci

University of Parma, Italy

Co-Author(s): Matteo Focardi; Caterina Ida Zeppieri

Abstract:

We study the asymptotic behavior of fractional Dirichlet energies in periodically perforated domains via De Giorgi's Gamma-convergence. In the critical regime, we identify the so-called strange term in the spirit of Cioranescu and Murat. The proof relies on a mesoscopic annular freezing procedure, localized fractional capacity estimates, and a bulk decoupling argument controlling the nonlocal interactions. We also characterize the subcritical and supercritical regimes: in the former the perforations are asymptotically invisible, while in the latter bounded-energy sequences collapse to zero.

On a Sobolev critical problem for the superposition of a local and nonlocal operator with the wrong sign

Schedule: July 9 9:30-10:00 Room 421

Eugenio Vecchi

ALMA MATER STUDIORUM - Universita' di Bologna, Italy

Abstract:

In this talk I will focus on a Sobolev critical problems in a bounded domain where the operator is given by $-\Delta - (-\Delta)^s$ with $s \in (0, 1)$, possibly losing the maximum principles. I will discuss the existence of at least one non trivial solution. The talk is based on a joint work with S. Biagi, S. Dipierro and E. Valdinoci.

Special Session 71 : Progress in Partial Differential Equations of Mathematical Physics: Theory and Methods

Organizer(s): Andreas Chatziafratis , Spyridon Kamvissis , Tohru Ozawa

Introduction: The central theme of this session is the rigorous study of initial and of boundary value problems for (systems of) linear and nonlinear equations which arise in mathematical physics. Cutting-edge methods for the analysis of PDE that will be discussed mostly draw on tools from complex, harmonic and functional analysis and potential theory. A diverse array of select scholars shall present state-of-the-art research results which pertain to asymptotics, instabilities, well-posedness, controllability, analyticity, smoothing and other qualitative properties of solutions. Within this session's broad scope fit techniques and advances related to scattering, soliton and spectral theory, semi-classical and microlocal analysis, variational and perturbation approaches, Hamiltonian and integrable systems, Lax pairs, Riemann-Hilbert factorization problems, Toda lattices, and so on. Recent developments thanks to the Fokas unified transform method for initial-boundary-value problems for linear and integrable PDE (including, among others, evolution and dispersive equations as well as elliptic ones) on a variety of domains and configurations (e.g. intervals, quarter-planes, non-self-adjoint, moving-boundary and interface problems, nonlocal data, etc.) shall comprise an important component of this session.

On the nonlinear Schrödinger equation on the half line: analysis and numerical solution

Schedule: July 10 8:00-8:30 Room 316

Dimitra Antonopoulou

National and Kapodistrian University of Athens, Greece

Abstract:

We consider the NLS equation with a cubic nonlinearity posed on the half line. In the defocusing case, we prove that if the Dirichlet data have a sufficient polynomial decay then the Neumann data also have a proper decay so that the Fokas method is applicable. Moreover, we prove that the solution in the L^4 space norm converges to 0 as $t \rightarrow \infty$ establishing also the absence of solitons for this case. In the focusing case, decay of the Neumann data is proven (for properly decaying Dirichlet data), but only under the assumption of decay of the solution as $t \rightarrow \infty$. A Crank-Nicolson finite differences nonlinear scheme is introduced for the numerical solution of the problem on the positive semi-axis with experimental rates of convergence of order 2. We present numerical simulations for the soliton propagation with various initial conditions. The results are joint with Spyros Kamvissis.

Extreme Superposition: Rogue Waves of Infinite Order, Universality, and Anomalous Temporal Decay

Schedule: July 10 8:30-9:00 Room 316

Deniz Bilman

University of Cincinnati, USA

Abstract:

Focusing nonlinear Schrödinger equation serves as a universal model for the amplitude of a wave packet in a general one-dimensional weakly-nonlinear and strongly-dispersive setting that includes water waves and nonlinear optics as special cases. Rogue waves of infinite order are a novel family of solutions of the focusing nonlinear Schrödinger equation that emerge universally in a particular asymptotic regime involving a large-amplitude and near-field limit of a broad class of solutions of the same equation. In this talk, we will present several recent results on the emergence of these special solutions along with their interesting asymptotic and exact properties. Notably, these solutions exhibit anomalously slow temporal decay and are connected to the third Painlevé equation. Finally, we will extend the emergence of rogue waves of infinite order to the first several flows of the AKNS hierarchy--allowing for arbitrarily many simultaneous flows. Time permitting, we will report on recent work regarding their space-time asymptotic behavior under an arbitrary flow from the hierarchy.

Bore Propagation Models

Schedule: July 10 9:00-9:30 Room 316

Jerry L Bona

University of Illinois at Chicago, USA

Abstract:

We sketch the development of models for bore propagation on rivers. We offer an analysis of one of the most comprehensive models.

The Unified Transform Method for variable-coefficient equations

Schedule: July 10 9:30-10:00 Room 316

Bernard Deconinck

University of Washington, USA

Co-Author(s): Matthew Farkas

Abstract:

The Unified Transform Method or Method of Fokas has been successful in explicitly solving interface problems for constant coefficient linear evolution equations. Stated differently, the method can solve linear evolution equations with piecewise constant coefficients. Such problems arise in lots of applications. Even more important are linear evolution equations with spatially variable coefficients. I will show how by considering the limit of piecewise-constant coefficient problems, we may obtain explicit solution representations for variable coefficient problems.

Some remarks on the semiclassical asymptotics of eigenvalues and resonances for matrix-valued operators

Schedule: July 10 11:00-11:30 Room 316

Setsuro SF Fujiie

RITSUMEIKAN UNIVERSITY (Department of Mathematical Science), Japan

Abstract:

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Initial and boundary value problems for dispersive equations

Schedule: July 10 10:30-11:00 Room 316

Alex Himonas

University of Notre Dame, USA

Abstract:

In this talk we discuss the solving of initial and boundary value problems for dispersive evolution equations. Models of such equations are the nonlinear Schrödinger equation, the Korteweg-de Vries equation, and dispersive regularizations of Camassa-Holm type equations. For data in Sobolev spaces, we will present optimal well-posedness results based on sharp multilinear estimates motivated by estimating the solution of the forced linear problem in Bourgain solution spaces. Also, we shall present some implications of these estimates in the analytic theory of these equations.

New transform methods for doubly connected planar domains

Schedule: July 10 11:30-12:00 Room 316

Jesse Hulse

University of Manitoba, Canada

Abstract:

A new transform-based technique that generalizes the Unified Transform Method is developed for bounded doubly connected domains as a novel way to numerically solve boundary value problems for holomorphic functions and solutions to the Laplacian. This work utilizes the Szegő kernel for the annulus and generalizes methods for circular and simply connected domains developed by Crowdy (2015) and H., Lanzani, Llewellyn Smith, and Luca (2025). Time permitting, an application will be shown.

Models of soliton gas for the AKNS hierarchy

Schedule: July 10 12:00-12:30 Room 316

Robert Jenkins

University of Central Florida, USA

Abstract:

In this talk I will present a collection of recent results on modeling soliton gas. Specifically, I describe how one can take an N -soliton solution of any equation in the AKNS hierarchy and pass in the $N \rightarrow \infty$ limit to a particular model of soliton gas by making certain reasonable assumptions on the asymptotic density of eigenvalues and the norming constants which define the N -soliton spectrally. Time permitting I will discuss some results on the large time evolution of such solutions,

Existence of traveling wave solutions for the nonlocal derivative nonlinear Schrödinger equation

Schedule: July 10 13:30-14:00 Room 316

Mukhtar Karazym

Nazarbayev University, Kazakhstan

Co-Author(s): Amin Esfahani, Adilbek Kairzhan

Abstract:

We are interested in traveling wave solutions of the nonlocal derivative nonlinear Schrödinger (nonlocal DNLS) equation

$$iut - u_{xx} - b|u|^2u + i\alpha|u|^2u_x + i\beta u^2\bar{u}_x + \gamma u \partial_x \mathcal{H}(|u|^2) = 0,$$

where $b, \alpha, \beta, \gamma \in \mathbb{R}$ are parameters, and $\mathcal{H}$ denotes the Hilbert transform

$$\mathcal{H}u(x, t) = \frac{1}{\pi} \text{p. v.} \int_{\mathbb{R}} \frac{u(y, t)}{x - y} dy.$$

Depending on the sign of the parameters, we consider subcritical and critical minimization problems. Our main techniques are the Nehari manifold method and the concentration-compactness principle of P.L. Lions.

New transform methods for boundary value problems in planar domains

Schedule: July 10 14:00-14:30 Room 316

Elena Luca

The Cyprus Institute, Cyprus

Co-Author(s): Jesse J. Hulse (University of Manitoba), Loredana Lanzani (University of Bologna), Stefan G. Llewellyn Smith (University of California San Diego)

Abstract:

The Unified Transform Method (UTM), introduced by A.S. Fokas in the late 1990s, is a method for analyzing boundary value problems for linear and integrable nonlinear PDEs. Since its inception, the UTM has attracted significant attention within the mathematics community and has been extended to address a wide range of problems. For Laplace's equation, Fokas and Kapaev (2003) developed a transform method for boundary value problems in simply-connected convex polygons. Their approach initially utilized various techniques, including spectral analysis of parameter-dependent ODEs and Riemann--Hilbert methods. Later, Crowdy (2015) showed that this method can be reformulated within a complex function-theoretic framework, leading to the construction of new transform pairs tailored to circular domains (domains bounded by circular arcs, with convex polygons as a special case). We present a new transform-based approach for boundary value problems for Laplace's equation in more general planar domains, specifically in simply connected Lipschitz domains (including non-convex domains). The key ingredient is the exploitation of the properties of the Szegő kernel and its connection with the Cauchy kernel, which enables the construction of transform pairs for analytic functions in such domains. Several examples are presented, together with numerical implementations illustrating the effectiveness of the transform pairs.

Homogenization results for the nonlinear Schrödinger equation

Schedule: July 10 14:30-15:00 Room 316

Maria Ntekoume

Concordia University, Canada

Co-Author(s): Benjamin Harrop-Griffiths

Abstract:

The cubic nonlinear Schrödinger equation (NLS) arises as a model for the propagation of intense continuous wave laser beams in a homogeneous medium. In practice, it has also been successful in modeling optical experiments in inhomogeneous settings. This suggests the occurrence of homogenization, that is, in a large scale limit, solutions to the inhomogeneous equation converge to the solution of a homogeneous NLS. We will review some recent homogenization results for physically motivated examples. While materials with a periodic structure are the most natural setting to consider this problem, our examples include a model where strong defects are sprinkled randomly across the medium. Part of this talk is based on joint work with B. Harrop-Griffiths.

Uncovering bistability phenomena in two-layer Couette flow experiments using nonlocal evolution equations

Schedule: July 10 15:00-15:30 Room 316

Demetrios T Papageorgiou

Imperial College London, England

Co-Author(s): Xingyu Wang, Department of Mathematics, Imperial College London
Pierre Germain, Faculty of Mathematics, Universitat Wien

Abstract:

The stability of interfacial long waves in two-layer plane Couette flow is investigated using a nonlinear, nonlocal asymptotic model derived from the Navier-Stokes equations and valid for thin upper layers. Nonlocality enters through a coupling of the thin and main layers, and crucial inertial effects are retained. The models generically support bistability phenomena observed in experiments where two stable travelling waves, one unimodal and the other bimodal, are recorded at the same lid velocity. In direct comparisons with experiments, the models show remarkable agreement, both qualitatively and quantitatively. The two stable travelling waves are identified, and their basins of attraction characterised via large-time computations for different initial conditions. We also identify a new symmetry-breaking travelling-wave branch bifurcating from the bimodal family, compute higher-wavenumber travelling-wave branches, and present time-periodic orbits arising via Hopf bifurcations.

The surprising world of third-order dispersion

Schedule: July 10 15:30-16:00 Room 316

Beatrice Pelloni

Heriot-Watt University, Scotland

Abstract:

I will describe the solution of third-order dispersive equations when the initial condition has low regularity, for a variety of boundary conditions.

On the critical lengths and controllability of the Kawahara equation

Schedule: July 10 16:30-17:00 Room 316

Lionel ROSIER

Universite du Littoral Cote d'Opale, France

Co-Author(s): Fagner D. Araruna and Gleb G. Doronin

Abstract:

This paper deals with the exact controllability of the Kawahara equation posed on a finite interval with one boundary control. We prove that the local exact controllability of Kawahara equation holds provided that the length of the interval does not belong to a countable set of critical lengths.

Scale invariant regularity estimates for the Neumann problem in Lipschitz domains

Schedule: July 10 17:00-17:30 Room 316

Georgios Sakellaris

Aristotle University of Thessaloniki, Greece

Abstract:

We will discuss the Neumann Green function and scale invariant regularity estimates for the equation $-\operatorname{div}(A\nabla u + bu) + c\nabla u + du = -\operatorname{div}f + g$ with Neumann data in Lipschitz domains $\Omega \subseteq \mathbb{R}^n$. Under the assumption that A is elliptic and bounded, we will see a necessary structural condition on the lower order coefficients that guarantees at most one dimensional kernels, as well as boundedness close to the boundary. Under the optimal assumptions $b, c \in L^n$ and $d \in L^{n/2}$, we will then show estimates for the L^2 theory that are scale invariant: that is, they depend only on the norms of the coefficients and the Lipschitz character of Ω . One difficulty will be the existence of nontrivial kernels, which will differentiate the theorems considered, but this will be identified by a specific integral of the coefficient d . We will also discuss the analogue of Green's function for the Neumann problem, called the Neumann Green function, and show that it satisfies scale invariant estimates in appropriate weak L^p spaces. These estimates will lead to scale invariant local boundedness, under specific assumptions for the Neumann data in Lorentz spaces that are both necessary and optimal.

Higher order dispersive equations on the half-line

Schedule: July 10 17:30-18:00 Room 316

Fangchi Yan

Virginia Tech, USA

Co-Author(s): Alex Himonas

Abstract:

In this talk, we study initial-boundary value problems for nonlinear dispersive equations with higher order dispersion on the half-line. Such problems arise naturally in physical models where wave propagation is influenced by both nonlinear effects and dispersion. Our approach is based on the Fokas method, which provides a systematic framework for solving the associated linear problems. Using this method, we establish optimal well-posedness results for a class of higher order nonlinear Schrödinger and KdV-type equations.

Special Session 72 : Fluid-structure interaction and free boundary problems

Organizer(s): Igor Kukavica , Arnab Roy , Boris Muha

Introduction: The interaction between fluids and solid structures, along with free boundary problems, is a fundamental area of applied mathematics with far-reaching applications in engineering, physics, and biological systems. This special session aims to bring together researchers studying both the theoretical and numerical aspects of fluid-structure interaction (FSI) and free boundary problems. On the theoretical front, we will delve into well-posedness, stability, asymptotic behavior, and control of FSI models, as well as the mathematical challenges that arise from coupling incompressible or compressible fluids with elastic or rigid structures. On the numerical side, we will explore recent advances in computational methods for simulating FSI and free boundary problems, addressing challenges in accuracy, efficiency, and stability. We will also consider the broader class of free boundary problems involving fluid equations, with an emphasis on well-posedness, asymptotics, and control. By bridging theory and computation, this session aims to foster collaboration among researchers tackling different facets of these intricate and highly interdisciplinary problems.

Local well-posedness of a model for fluidic elastic membranes

Schedule: July 9 14:00-14:30 Room 642

Helmut Abels

University of Regensburg, Germany

Co-Author(s): Yadong Liu, Andrea Poiatti

Abstract:

We consider a system consisting of a surface Navier-Stokes equation for incompressible fluids on an elastic inextensible membrane, whose evolution is coupled to the flow of the fluid on the surface. This leads to a highly nonlinear quasilinear geometric evolution equation of parabolic-hyperbolic type. Using a suitable parametrization we linearize the system and obtain well-posedness of it in suitable L^2 -type Sobolev spaces. With the aid of a suitable fixed-point argument we show existence of strong solutions locally in time.

Analysis and numerics of a fully averaged poroelastic plate model and its interaction with a fluid

Schedule: July 9 9:00-9:30 Room 642

Felix Brandt

University of California, Berkeley, USA

Co-Author(s): Sun\\v{c}ica \\v{C}ani\\c, Andrew Scharf, Josip Tamba\\v{c}a

Abstract:

In the first part of this talk, we derive a fully averaged poroelastic plate model. We discuss the existence of weak and mild solutions using a semigroup approach and propose a splitting scheme for the numerical analysis, comparing our model to existing poroelastic plate models. The second part of the talk addresses the interaction problem of the fully averaged plate model with a Stokes fluid. We first prove the existence of weak solutions using energy methods and then show the existence of a unique strong solution to a regularized version of the problem. This is achieved by establishing the sectoriality of the associated operator matrix with a non-diagonal domain, thereby paving the way for maximal L^p -regularity of the corresponding Cauchy problem. Finally, we derive a finite element method for the numerical approximation of the coupled problem and demonstrate its effectiveness in capturing the interaction between the fluid and the poroelastic plate. This talk is based on joint work with S. \\v{C}ani\\c, A. Scharf, and J. Tamba\\v{c}a.

On the long time behavior of a family of several rigid bodies immersed in a viscous fluid

Schedule: July 9 8:00-8:30 Room 642

Eduard Feireisl

Institute of Mathematics, Czech Academy of Sciences, Czech Rep

Co-Author(s): Marco Bravin, Arnab Roy, Arghir Zarnescu

Abstract:

We consider several rigid bodies immersed in a viscous Newtonian fluid contained in a bounded domain in R^3 . We introduce a new concept of dissipative weak solution of the problem based on a combination of the approach proposed by Judakov with a suitable form of energy inequality. We show that global in time dissipative solutions always exist as long as the rigid bodies are connected compact sets. In addition, in the absence of external driving forces, the system always tends to a static equilibrium as time goes to infinity. The results hold independently of possible collisions of rigid bodies and for any finite energy initial data.

On 3D Navier-Stokes helical vortex filament

Schedule: July 9 8:30-9:00 Room 642

Francisco Gancedo

Universidad de Sevilla, Spain

Abstract:

Vortex filaments are fundamental structures in three-dimensional incompressible fluid dynamics, capturing the concentration of vorticity along curves and providing a natural framework for the analysis of coherent structures. Understanding their evolution under the 3D Navier-Stokes equations remains a challenging problem, especially in regimes where geometric features of the flow play a significant role. In this talk, we consider vortex filaments with helical structure, which arise naturally in flows exhibiting symmetry and offer a tractable setting to investigate the interplay between geometry and diffusion. Our analysis applies to vortex filaments of arbitrary size and without vanishing swirl assumption. After introducing the mathematical formulation of the problem and the main analytical difficulties, we present new results concerning the existence, uniqueness, and evolution of such helical vortex filaments in the Navier-Stokes setting.

On the dynamics of a fluid-structure interaction problem

Schedule: July 9 14:30-15:00 Room 642

Rafael Granero Belinchon

Universidad de Cantabria, Spain

Abstract:

In this talk we will present some new results for a fluid-structure problem. In particular, we will present the equations describing the dynamics. These new PDEs present a double nonlinear structure where the nonlinearity affects also to the time derivative of the solution. Furthermore, we will present their mathematical well-posedness theory.

Analysis of a Fluid-Poroviscoelastic Interaction Problem

Schedule: July 9 13:30-14:00 Room 642

Matthias Hieber

TU Darmstadt, Germany

Co-Author(s): Tim Binz and Arnab Roy

Abstract:

In this talk we discuss a coupled viscoelastic Navier-Stokes-Biot system describing the interaction between an incompressible, viscous fluid and a poro-viscoelastic medium. The coupling is realized through Beavers-Joseph-Saffman type interface conditions. We establish the global wellposedness of this system in the strong sense for small initial data and derive in addition a Serrin-type blow-up criterion.

The vanishing viscosity limit in permeable domains

Schedule: July 9 16:30-17:00 Room 642

Anna L Mazzucato

Penn State University, USA

Abstract:

I will discuss the zero-viscosity limit in domains that allow inflow and outflow for both the Navier-Stokes as well as the Boussinesq equations.

On the problem of compressible fluid-structure interaction with Navier boundary conditions

Schedule: July 9 15:00-15:30 Room 642

Sarka Necasova

Czech Academy of Sciences, Czech Rep

Co-Author(s): K. Bhandari, I. Djebour, S.Mitra, Y.Liu,

Abstract:

In the talk, we will focus on the problem of compressible barotropic fluid with elastic structure and with Navier boundary conditions. We show the existence of weak solutions, a singular limit to the inviscid case. This part of the talk is based on collaboration with S. Mitra and Y. Liu. Moreover, we show the existence of a strong solution and the uniqueness of the strong solution. It is based on the work with K. Bhandari and I. Djebour.

Thermal effects in fluid structure interactions

Schedule: July 9 17:00-17:30 Room 642

Sebastian Schwarzacher

Uppsala University/Charles University, Sweden

Abstract:

In this lecture we consider two different heat conducting fluids each modelled by the incompressible Navier-Stokes-Fourier system separated by a non-linear elastic Koiter shell. The motion of the shell changes the domain of definition of the two separated fluids. For this setting we discuss the existence of a weak solution. The heat capacity of the shell is given energetically. It allows to consider transmission laws ranging from insulation to superconductivity. A variational approach for fluid-structure interaction is used. This method seems particularly useful for elastodynamics, for which also some results will be discussed in the lecture. The lecture is based on a joint work with Sourav Mitra.

The 3D Kutta-Joukowski effect

Schedule: July 9 9:30-10:00 Room 642

Franck Sueur

University of Luxembourg, France

Co-Author(s): Olivier Glass, David Meyer

Abstract:

In this talk, I will present a joint work with Olivier Glass and David Meyer on the 3D counterpart of the well-known 2D Kutta-Joukowski effect, experimented by a rigid body moving in a perfect incompressible fluid.

Finite-time contact in fluid-elastic structure interactions

Schedule: July 9 17:30-18:00 Room 642

Krutika Tawri

University of Washington, USA

Co-Author(s): Nash Ward

Abstract:

In this talk, we will consider a fluid-structure interaction problem involving a viscous, incompressible fluid flow, modeled by the 2D Navier-Stokes equations, through a thin deformable elastic tube, elastodynamics of which is modeled by 1D plate equations. The fluid and the structure are nonlinearly coupled at the fluid-structure interface. The fluid flow is driven by dynamic pressure data imposed at the inlet and the outlet of the tube. In this talk, we will impose the Navier-slip boundary condition at the fluid-structure interface and at the bottom rigid boundary of the fluid domain. We will first discuss the existence of weak solutions and reveal a 'hidden' spatial regularity result for the structure displacement. Then we will discuss our recent result that establishes the existence of a finite time for the weak solutions at which the compliant upper boundary meets the lower boundary (i.e., the tube collapses), provided that there is a sufficient pressure drop across the channel. This resolves the "no-collision" paradox identified in the no-slip setting and thus validates the model to correctly capture near-contact dynamics.

Contact in fluid-plate interaction: formation and detachment

Schedule: July 9 18:00-18:30 Room 642

Srdan Trifunovic

Faculty of Sciences, University of Novi Sad, Yugoslavia

Abstract:

In this talk, I will present a recent result on contact problem for the interaction between an elastic plate and a compressible viscous fluid located between the plate and a rigid bottom $z = 0$. First, by utilizing the vertical fluid dissipation, a new estimate is obtained $\ln \eta(t) \in L^1$ for any $t > 0$ provided that $\ln \eta_0 \in L^1$, ensuring that additional contact can form only on a set of a measure zero. Then, by utilizing the expanding capability of compressible fluid pressure, it is shown that all contact has to detach in finite time provided that the source force is not pushing down too much. Finally, it is shown that contact at any point can be detached in any given time with a strong enough source force localized around that point which is pulling the plate up. This is the first result where detachment of contact is proven.

Special Session 74 : Recent advances in local and nonlocal PDEs

Organizer(s): Eugenio Vecchi , Stefano Biagi

Introduction: Local and nonlocal PDEs find applications in a variety of fields, from purely theoretical to more applied ones in mathematics, physics, engineering, biology, finance and many others. The aim of this special session is to present the most recent advances in both local and nonlocal PDEs of either elliptic or parabolic type focusing on regularity theory, existence and uniqueness of solutions as well as qualitative properties of solutions. It will be a nice opportunity to have experts in these areas allowing for an open exchange of ideas in this wide area of mathematical analysis which may give rise to future research directions.

Regularity results for nonlinear Fokker-Planck equations

Schedule: July 8 9:00-9:30 Room 315

Francesca Anceschi

Universita' Politecnica delle Marche, Italy

Abstract:

In this talk, we focus on the study of a class of kinetic equations, whose prototype is the nonlinear Kolmogorov-Fokker-Planck equation. Through a geometrical approach, we prove a Poincaré inequality for weak solutions, a fundamental result for the study of the weak regularity theory and the consequent proof of a weak Harnack inequality. The talk is based on two joint works, the first one in collaboration with Dietert, Guerand, Loher, Mouhot and Rebucci, and the second one with Guerand and Isernia.

Complete stickiness for nonlocal minimal graphs with obstacles in highly nonlocal regimes

Schedule: July 8 15:00-15:30 Room 315

Claudia D Bucur

University of Milan, Italy

Co-Author(s): Luca Lombardini

Abstract:

We study the geometric and functional framework for a nonlocal Plateau problem with obstacles. In particular, we formulate the minimization of the fractional perimeter in cylinders with respect to graphical exterior data, as well as the equivalent variational problem for the nonlocal area functional. We then show that, when the prescribed exterior data is not too large at infinity and the fractional parameter is sufficiently small, minimizers exhibit complete stickiness: they adhere entirely to the obstacle and leave the remainder of the domain asymptotically empty.

Replicator dynamics with genetic drift as the large population limit of a discrete Moran process

Schedule: July 8 17:30-18:00 Room 315

Riccardo Durastanti

Universita degli Studi di Napoli Federico II, Italy

Abstract:

We study the large population limit of a multi-strategy discrete-time Moran process in the weak selection regime. By applying an appropriate simultaneous rescaling of the population size, the time step, and the selection regime, we derive the replicator dynamics with genetic drift. We rigorously prove the existence of a very weak solution for the resulting limit equation: a parabolic nonlocal equation characterized by a degenerate principal operator of Fleming-Viot type. This is a joint work with S. Almi, M. Morandotti, G. Orlando and F. Solombrino.

Critical problems in Carnot groups

Schedule: July 8 15:30-16:00 Room 315

Mattia Galeotti

University of Bologna, Italy

Co-Author(s): Biagi, Stefano AND Vecchi, Eugenio

Abstract:

A vast literature addresses problems involving the Laplacian operator of the kind

$$-\Delta u = \lambda u^s + u^p \quad \text{in } \Omega \subseteq \mathbb{R}^N,$$

the main focus being the existence of positive solutions (vanishing at the boundary) when the nonlinearity hits the critical Sobolev exponent $2^* = \frac{2N}{N-2}$. In both the singular case with $s \in (-1, 0)$ and the concave-convex case with $s \in (0, 1)$, there exists a threshold $\Lambda > 0$ such that the problem admits at least two solutions for $\lambda \in (0, \Lambda)$ and admits no solutions for $\lambda > \Lambda$. For $\lambda = \Lambda$ at least one solution exists. In two recent works (joint with Biagi-Vecchi and Vecchi), we consider the same problem but in a Carnot group G , where the operator is the sub-Laplacian $-\Delta_G$, and prove an analogous behaviour to the Euclidean case. In this sub-Riemannian setting, the critical case is $2_G^* = \frac{2Q}{Q-2}$ where Q is the homogeneous dimension of G . In the singular case, we obtain the first solution via Perron's method and the second by adapting an argument by Tarantello, with new estimates for the group convolution and for substitutes of the Aubin--Talenti functions. In the concave-convex case, the minimality argument for the first solution relies on regularity results available in the Euclidean setting but not in the sub-Riemannian one; to overcome this, we develop an ad hoc variational approach.

Singular p-Laplacian problems with discontinuous convection terms

Schedule: July 8 16:30-17:00 Room 315

Umberto Guarnotta

University of Catania, Italy

Co-Author(s): Salvatore A. Marano

Abstract:

The talk is devoted to discuss existence of solutions to a p-Laplacian problem whose reaction is singular (i.e., it blows up when the solution approaches zero), convective (that is, it depends on the gradient of the solution), and possesses a null-measure set of discontinuity points. The techniques presented are based on regularization arguments, monotonicity techniques, regularity theory, locality properties, and measure-theoretical arguments.

Qualitative Properties to Anisotropic Parabolic PDEs

Schedule: July 8 14:00-14:30 Room 315

Eurica Henriques

Universidade Trás os Montes e Alto Douro, CMAT, Portugal

Co-Author(s): Igor I. Skrypnik, Mariia Savchenko, Simone Ciani

Abstract:

In this talk we discuss qualitative properties of weak solutions to a class of nonlinear anisotropic parabolic partial differential equations. These equations arise in models where diffusion may behave differently in each spatial direction, leading to operators with direction-dependent growth and nonstandard structure. These results illustrate how classical tools from the De Giorgi-Nash-Moser theory can be adapted to anisotropic frameworks, providing a general approach to the study of nonlinear parabolic problems with direction-dependent diffusion.

TRAVELING MOTILITY OF ACTIN LAMELLAR FRAGMENTS UNDER SPONTANEOUS SYMMETRY BREAKING

Schedule: July 8 17:00-17:30 Room 315

Martina Magliocca

Universidad de Sevilla, Spain

Abstract:

Cell motility is connected to the spontaneous symmetry breaking of a circular shape. In [1] Blanch-Mercader and Casademunt performed a nonlinear analysis of the minimal model proposed by Callan and Jones [2] and numerically conjectured the existence of traveling solutions once that symmetry is broken. In this talk, we prove analytically that conjecture by means of nonlinear bifurcation techniques.

Existence and non-existence of radial solutions for the subcritical Lane-Emden equation on model manifolds

Schedule: July 8 13:30-14:00 Room 315

Matteo Muratori

Politecnico di Milano, Italy

Co-Author(s): A. De Luca, N. Soave

Abstract:

We investigate existence and non-existence of positive radial solutions for the subcritical Lane-Emden equation $-\Delta_{\mathbb{M}^n} u = u^q$ on a class of non-compact Riemannian models $\mathbb{M}^n$. A number of interesting phenomena arise: depending on the volume growth, which is required to be polynomial, the subcritical regime divides into three ranges, characterized by existence (slightly subcritical), non-existence (strongly subcritical), and by a mixed behavior where existence and non-existence depend in a very sensitive way on the underlying manifold (intermediate). As a byproduct of our methods of proof we also show that, in some cases, the radial homogeneous Dirichlet problem in geodesics balls can have multiple positive solutions, in contrast with both the Euclidean and the hyperbolic space.

Relaxed uniqueness conditions for the parabolic Schrodinger equation on Riemannian manifolds

Schedule: July 8 8:30-9:00 Room 315

Fabio Punzo

Politecnico di Milano, Italy

Abstract:

In this talk, I will present some uniqueness results for the Cauchy problem for the parabolic Schrodinger equation on complete noncompact Riemannian manifolds. Under suitable assumptions on the potential V , we show that the integral condition required for uniqueness may be significantly weaker than in the case with no potential. The key idea is to exploit the decay of positive solutions to the corresponding stationary Schrodinger equation.

Regularity estimates for 0-order p-Laplacian evolution problems

Schedule: July 8 14:30-15:00 Room 315

Ariel Salort

CEU San Pablo, Madrid, Spain

Co-Author(s): Matteo Bonforte

Abstract:

We establish novel smoothing estimates and enhanced temporal regularity for a class of nonlinear nonlocal operators, characterized as order zero p -Laplacians. A key finding of this work is that the linear evolution ($p = 2$) fails to satisfy the smoothing estimates that we prove to exist for the nonlinear regime. Furthermore, we demonstrate that these evolutions preserve local spatial regularity up to order p . This is a joint work with M. Bonforte (UAM, Spain).

Liouville type theorem for semilinear equations on weighted graphs

Schedule: July 8 9:30-10:00 Room 315

Jacopo Somaglia

Politecnico di Milano, Italy

Co-Author(s): Dario Monticelli and Fabio Punzo

Abstract:

We study semilinear elliptic inequalities on infinite weighted graphs. Given a distance on the graph, assuming an upper bound on its Laplacian, and a growth condition on a suitable weighted volume of balls, we show that the following semilinear elliptic inequality

$$\Delta u + v(x)u \leq 0,$$

where v is a positive potential, admits no nonnegative solution. The parabolic case is also discussed. This is a joint work with Dario Monticelli and Fabio Punzo.

Liouville theorems for linear operators with linear drift

Schedule: July 8 8:00-8:30 Room 315

Giulio Tralli

University of Ferrara, Italy

Abstract:

In this talk we discuss the validity of Liouville theorems for non-negative solutions to hypoelliptic equations with constant diffusion and linear drift. Assuming that the drift term has imaginary spectrum, we show such one-sided Liouville property as a by-product of an invariant Harnack inequality for ancient solutions to parabolic equations of Kolmogorov type. We focus on the role of the large-scale geometry associated to the drift: the relevance of the hypoelliptic class under discussion (even for the case of elliptic operators) appears naturally in our approach. The talk is based on a joint work with A.E. Kogoj and E. Lanconelli.

Advances in symmetrization methods for nonlocal problems

Schedule: July 8 18:00-18:30 Room 315

Bruno Volzone

Politecnico di Milano, Italy

Abstract:

This talk will be the occasion to discuss a summary of results about the application of symmetrization methods to nonlocal equations. The first part will mainly treat results about linear and nonlinear elliptic equations obtained in the first two joint works with V. Ferone, while the second (and last) part will be focused to the description of some recent results flourished in a broader project with V. Ferone, I. De Bonis, B. Brandolini and G. Piscitelli which mainly deal with nonlocal singular elliptic/parabolic problems, stable-like nonlocal operators and fractional eigenvalues.

Special Session 77 : Singularity and regularity in nonlinear PDEs

Organizer(s): Berikbol Torebek , Matteo Muratori

Introduction: This session explores the interplay between singularity formation and regularity in nonlinear partial differential equations (PDEs), which are central to modeling complex physical, biological, and geometric phenomena. Nonlinear PDEs often exhibit intricate solution behavior, where smooth initial data can lead to singularities — points where the solution becomes undefined, discontinuous or blows up — in finite time. Conversely, under certain structural conditions, these equations may admit globally regular and bounded solutions.

Helical vortex structures with compactly supported cross-sectional vorticity for the 3D incompressible Euler equations

Schedule: July 7 18:00-18:30 Room 432

Averkios Averkiou

University of Bath, England

Co-Author(s): Monica Musso

Abstract:

In this talk, we first revisit the vortex filament conjecture for three-dimensional incompressible Euler flows with helical symmetry and no swirl. By adapting gluing methods, we obtain the first construction of a smooth helical vortex filament in the whole space $\mathbb{R}^3$ whose cross-sectional vorticity remains compactly supported in $\mathbb{R}^2$ for all times. Building on this construction, we then investigate the leapfrogging phenomenon of helical vortex filaments, in which several interacting vortex helices with a common symmetry axis alternately overtake one another while preserving their coherent structure. This is joint work with Monica Musso.

Weighted Hardy-Rellich inequalities via the Emden-Fowler transform

Schedule: July 7 9:00-9:30 Room 432

Elvise Berchio

Politecnico di Torino, Italy

Co-Author(s): Paolo Caldirolì

Abstract:

We exploit a technique based on the Emden-Fowler transform to prove optimal Hardy-Rellich inequalities on cones, including the punctured space and the half space as particular cases. We find optimal constants for classes of test functions vanishing on the boundary of the cone and possibly orthogonal to prescribed eigenspaces of the Laplace Beltrami operator restricted to the spherical projection of the cone. Furthermore, we show that extremals do not exist in the natural function spaces. Depending on the parameters, certain resonance phenomena can occur. For proper cones, this is excluded when considering test functions with compact support. Finally, for suitable subsets of the cones we provide improved Hardy-Rellich inequalities, under different boundary conditions, with optimal remainder terms.

Wasserstein Theory in a Goulash Medium

Schedule: July 7 13:30-14:00 Room 432

Iwona Chlebicka

University of Warsaw, Poland

Abstract:

When a medium has a nontrivial heterogeneous structure of a goulash, the tools to model diffusion in it is in a short supply. Driven by the idea to describe its evolution as a gradient flow, we face deep structural challenges in a generalized Wasserstein theory.

Fujita's critical exponent for Fractional Reaction-Diffusion Systems on

$\mathbb{R}^N$

Schedule: July 7 17:00-17:30 Room 432

Soon-Yeong Chung

Sogang University, Seoul, Korea

Co-Author(s): Soon-Yeong Chung

Abstract:

In this talk, we are going to introduce Fujita's critical exponent to determine whether a fractional reaction-diffusion system (S) admits a global solutions or only blow-up solutions. In fact, the number $(pq)^*$ is introduced as the critical exponent to prove i If $(pq)^* < pq$, then (S) has a global solution for some initial data. ii If $(pq)^* \geq pq$, then every nontrivial and non-negative solution to (S) blows up in finite time.

Competing effects in fractional thin film equations

Schedule: July 7 17:30-18:00 Room 432

Antonio Esposito

University of L'Aquila, Italy

Abstract:

The talk concerns the analysis of fractional thin film equations with linear mobility and an aggregation term. The problem is posed in a bounded convex domain with homogeneous Neumann boundary conditions, in dimension $d \geq 1$. We study the existence of weak solutions by interpreting the problem as a 2-Wasserstein gradient flow of an energy functional presenting two competing effects: the fractional Dirichlet energy and the power-law internal energy. The seminar is based on a joint work with J. A. Carrillo, A. Massucco, and S. Lisini.

The asymptotic behaviour for solutions to an anisotropic diffusion equation in the slow diffusion regime

Schedule: July 7 16:30-17:00 Room 432

Filomena Feo

University of Naples Parthenope, Italy

Abstract:

In this talk, we will present some recent results concerning the nonnegative solutions of the following anisotropic equation

$$-\operatorname{div}(\mathbf{A}(x)\nabla u) = \sum_{i=1}^N (u^{m_i})_{x_i} \quad \text{in } \mathbb{R}^N \times (0, +\infty)$$

with $N \geq 2$ and $m_i > 0$ for $i = 1, \dots, N$. We focus on the slow ($m_i > 1$ for all i) diffusion in all directions. We examine, in particular, the existence and uniqueness of a self-similar fundamental solution and the asymptotic behavior of nonnegative solutions of the Cauchy problem with L^1 initial data. Based on some recent joint papers with J. L. Vázquez and B. Volzone.

Collision Bubbles for the Keller-Segel Model

Schedule: July 7 18:30-19:00 Room 432

Tej eddine Ghoul

New York university Abu Dhabi, United Arab Emirates

Abstract:

It is well known that the two-dimensional Keller-Segel system admits finite-time blow-up solutions when the initial density has total mass greater than 8π and finite second moment. Several constructive examples of such solutions have been obtained, all exhibiting the same mechanism: a perturbed stationary state undergoes a scale instability and collapses at a point, leading to the concentration of a mass 8π . It has long been conjectured that singular solutions involving the simultaneous concentration of more than one soliton could exist. In this work, we rigorously construct such a new blow-up mechanism. More precisely, we exhibit solutions in which two stationary states collapse simultaneously and collide, resulting in the concentration of a mass 16π at a single blow-up point.

Blow-up and stability for quadratic derivative nonlinear wave equations

Schedule: July 8 8:30-9:00 Room 432

Oliver Gough

University of Bath, England

Co-Author(s): Manuel del Pino, Monica Musso

Abstract:

This talk concerns finite-time blow-up in nonlinear wave equations with quadratic derivative nonlinearities. A central question is to understand the blow-up profile and mechanism in such equations, and whether the corresponding singular solutions continue to describe the dynamics under small perturbations. I will discuss recent work on these questions.

Existence of solutions to the fractional semilinear heat equation with a singular inhomogeneous term

Schedule: July 7 15:00-15:30 Room 432

Tatsuki Kawakami

Ryukoku University, Japan

Co-Author(s): Kazuhiro Ishige, Ryo Takada

Abstract:

In this talk, we study the existence of solutions to the fractional semilinear heat equation with a singular inhomogeneous term. To this end, we establish decay estimates for the fractional heat semigroup in several uniformly local Zygmund spaces. Furthermore, we apply the real interpolation method in uniformly local Zygmund spaces to obtain sharp integral estimates for the inhomogeneous and nonlinear terms. This enables us to derive sharp sufficient conditions for the existence of solutions to the fractional semilinear heat equation with a singular inhomogeneous term. This talk is based on joint work with Prof. K. Ishige (University of Tokyo) and Prof. R. Takada (University of Tokyo).

Aggregation-diffusion models with nonlinear potentials

Schedule: July 7 15:30-16:00 Room 432

Edoardo Mainini

University of Genoa, Italy

Co-Author(s): Francesco Bozzola

Abstract:

We investigate dynamics, stationary states and singular limits for aggregation diffusion models with nonlinear Riesz potentials. Radial stationary states of the dynamics are related with extremals of suitable Hardy-Littlewood-Sobolev inequalities. In the case that aggregation does not dominate over diffusion, radial stationary states also relate to global minimizers of the natural free energy functional. The evolution can be seen as the gradient flow of the free energy, and its analysis requires suitable gradient estimates for the nonlinear Riesz potential.

The Porous Medium Equation in Cones and Half-spaces

Schedule: July 8 9:00-9:30 Room 432

Troy Petitt

Universidad Carlos III de Madrid, Spain

Co-Author(s): Kazuhiro Ishige, Matteo Muratori, Troy Petitt

Abstract:

We consider existence, uniqueness, and asymptotics of the porous medium equation in cones and half-spaces with homogeneous Dirichlet boundary conditions. We find that solutions depend quantitatively on the aperture of the cone via the first Dirichlet eigenvalue. Along the way, we prove the existence and uniqueness of dipole solutions in general cones, i.e. solutions that take as an initial datum a Dirac delta measure on the point of the cone.

Propagation and Extinction for a KPP-Type Heat Equation on Regular Metric Trees

Schedule: July 7 14:00-14:30 Room 432

Fabio Punzo

Politecnico di Milano, Italy

Abstract:

We present some recent joint results with Alberto Tesei on the Cauchy-Neumann problem for a semilinear heat equation with a KPP-type forcing term on a regular metric tree. We investigate the propagation and extinction of solutions, as well as their asymptotic speed of propagation. Particular attention is devoted to the analogies and differences with related results in Euclidean and hyperbolic spaces.

The lifespan estimates of solutions to systems of weighted nonlinear wave equations in 1D

Schedule: July 7 8:30-9:00 Room 432

Hiroyuki Takamura

Tohoku University, Japan

Co-Author(s): Masakazu Kato, Takiko Sasaki

Abstract:

In this talk, I will introduce you harp lifespan estimates of solutions to systems of weighted nonlinear wave equations by time-variable in one space dimension. The targeted systems include Nakao type problem among wave and scale-invariant damped wave equations.

Mass concentration comparison for nonlinear diffusion on model manifolds

Schedule: July 8 9:30-10:00 Room 432

Bruno Volzone

Politecnico di Milano, Italy

Co-Author(s): Matteo Muratori

Abstract:

We investigate the validity of the mass concentration comparison for a class of nonlinear diffusion equations, commonly known as filtration equations, posed on Riemannian manifolds that are spherically symmetric, that is, model manifolds. Our main result states that, given any continuous bijection $\varphi : [0, +\infty) \rightarrow [0, +\infty)$, the filtration equation $\partial_t u = \Delta \varphi(u)$ satisfies the concentration comparison if and only if the underlying model manifold supports the P\'olya-Szeg\' inequality. As a simple corollary, the validity of such a comparison for the heat equation is sufficient to guarantee that the same holds for all filtration equations. Moreover, we prove that if the manifold supports a centered isoperimetric inequality then the P\'olya-Szeg\' inequality holds, allowing us to include important examples such as the hyperbolic space and the sphere. This is a joint work with Matteo Muratori.

Lifespan estimates for semilinear damped wave equation in a two-dimensional exterior domain

Schedule: July 7 9:30-10:00 Room 432

Yuta Wakasugi

Hiroshima University, Japan

Co-Author(s): Masahiro Ikeda, Motohiro Sobajima, Koichi Taniguchi

Abstract:

Consider the initial-boundary value problem for the two-dimensional semilinear damped wave equation with the critical nonlinearity $u_{tt} - \Delta u + u_t = u^2$ in the exterior of the unit ball in $\mathbb{R}^2$ with the Dirichlet boundary condition. We obtain a sharp double-exponential type lifespan estimate $T(\varepsilon) \geq \exp(\exp(C\varepsilon^{-1}))$ under the assumption of radial symmetry. To achieve this result, we introduce a new technique to control an L^1 -type norm and a new Gagliardo-Nirenberg type estimate with logarithmic weight.

Blow-up rate for the subcritical semilinear heat equation in non-convex domains

Schedule: July 7 14:30-15:00 Room 432

Erbol Zhanpeisov

Tohoku University, Graduate School of Science, Japan

Co-Author(s): Hideyuki Miura, Jin Takahashi

Abstract:

We study the blow-up rate for solutions of the subcritical semilinear heat equation. Type I blow-up means that the rate agrees with that of the associated ODE. In the Sobolev subcritical range, type I estimates have been proved for positive solutions in convex or general domains (Giga and Kohn, 1987; Quittner, 2021) and for sign-changing solutions in convex domains (Giga, Matsui and Sasayama, 2004). We extend these results to sign-changing solutions in possibly non-convex domains. The proof uses the Giga-Kohn energy together with a geometric inequality that controls the effect of non-convexity. As a corollary, we obtain blow-up of the scaling critical norm in the subcritical range. Based on joint work with Hideyuki Miura and Jin Takahashi (Institute of Science Tokyo).

Special Session 78 : Learning Approaches for PDE Forward and Inverse Problems

Organizer(s): Kui Ren

Introduction: Ideas and methodologies originating from machine learning have penetrated deeply into applied mathematics research in the past several years, resulting in the coupling of traditional physics-based modeling with the emerging data-driven modeling approaches of applied mathematics. In particular, various machine learning methods have been developed for solving forward and inverse problems of partial differential equations. This session intends to highlight recent advances in this fascinating research area.

Point Source Identification Using Singularity Enriched Neural Networks

Schedule: July 6 13:30-14:00 Room 634

Tianhao Hu

The Chinese University of Hong Kong, Hong Kong

Co-Author(s): Tianhao Hu, Bangti Jin, Zhi Zhou

Abstract:

Neural network-based methods have shown great promise in stably solving ill-posed inverse problems. In this work, we focus on the inverse problem of recovering point sources, an important class of applied inverse problems. Despite their potential, neural network-based methods for identifying point sources remain underdeveloped, primarily due to the inherent singularity of the solution. To address this challenge, we develop a novel neural algorithm for identifying point sources, utilizing the singularity enrichment technique. We employ the fundamental solution and neural networks to represent the singular and regular parts, respectively, and then minimize an empirical loss involving the intensities and locations of unknown point sources and the parameters of the neural network. Moreover, by combining the conditional stability argument of the inverse problem with the generalization error of the empirical loss, we conduct a rigorous error analysis of the algorithm. We demonstrate the effectiveness of the method with several challenging experiments.

Leveraging Multiple Scattering for Inverse Problems in Reflection Microscopy

Schedule: July 6 14:00-14:30 Room 634

Thomas Wasik

CNRS/ Ecole polytechnique, France

Co-Author(s): Thomas WASIK, Victor BAROLLE, Alexandre AUBRY, Josselin GARNIER

Abstract:

In microscopy, reflection-mode configurations offer greater flexibility than transmission ones, enabling imaging of thicker samples and in vivo applications. Reflection-mode Optical Diffraction Tomography (ODT), however, faces a well-known limitation: the corresponding inverse problem is ill-posed. In single-scattering regime, reflected waves from the medium capture only the spatial high-frequency components, while, in the multiple-scattering regime, the forward model is non-linear, complicating optimization-based reconstruction. Nevertheless, it can be shown that this multiple scattering effect reduces the filtering effect associated with reflection measurements. For instance, light scattered by background structures also encodes the spatial low-frequencies of foreground objects, making the reconstruction possible. We present a novel optimization framework for 3D refractive index reconstruction in reflection-mode microscopy. Our method leverages backscattered light from unknown background structures to reconstruct foreground refractive index distributions. Regularization, an appropriate solver and a temporal loss ensure convergence despite the non-convexity of the problem. Simulations demonstrate accurate recovery of both low and high spatial frequencies, overcoming the missing-cone problem occurring in transmission-mode imaging. We also show that multi-wavelength illumination is necessary for convergence, making reflection ODT computationally intensive but rewarding.

Special Session 80 : Functional inequalities and PDEs

Organizer(s): Gerassimos Barbatis , Lorenzo Brasco

Introduction: The session will focus on functional inequalities in Sobolev spaces and their interplay with the theory of Partial Differential Equations, in particular of parabolic and elliptic type. The aim of the session is to gather together experts in the field but also young research in order to present the most recent advances and to foster possible collaborations, especially by gathering together people having different point of views on the subjects. Among the topics considered, the session will focus on: existence/nonexistence issues for extremals of functional inequalities, both for classical and fractional order Sobolev spaces; stability issues; connections between functional inequalities and regularity of solutions to PDEs; geometric aspects of functional inequalities; gradient flows; mathematical models for classical and quantum mechanics.

Geometric Hardy inequalities on the Heisenberg group

Schedule: July 9 18:30-19:00 Room 428

Gerassimos Barbatis

National and Kapodistrian University of Athens, Greece

Co-Author(s): Marianna Chatzakou, Achilles Tertikas

Abstract:

We present some new L^p Hardy inequalities on the Heisenberg group which involve the distance to the boundary. We adopt an abstract approach which allows us to obtain inequalities with various distances. Some new Hardy inequalities for Carnot groups of step two are also established. The constants obtained are sharp. Joint work with M. Chatzakou and A. Tertikas

Fujita exponent for Hormander's vector fields

Schedule: July 9 14:30-15:00 Room 428

Marianna Chatzakou

Ghent University, Belgium

Co-Author(s): Aidyn Kassymov, Michael Ruzhansky

Abstract:

In the first part of the talk, on unimodular Lie groups, we study the global well-posedness of the heat equation with a time-dependent nonlinearity of the form $S_p(t)f(u)$. We obtain distinct nonexistence criteria according to the volume growth of the group (compact, polynomial, or exponential). In the specific case of the Heisenberg group $\mathbb{H}^n$, we also provide sufficient conditions; for the case of the first Heisenberg group $\mathbb{H}^1$ these coincide with the necessary ones. In the second part, we consider the same equation after dropping the group structure: the underlying space is $\mathbb{R}^n$ endowed with vector fields defining the operator and satisfying, among other assumptions, Hormander's condition. In both settings, when $f(u) = u^p$, we compute the so-called critical Fujita exponent.

Functional inequalities in weighted fractional Sobolev spaces

Schedule: July 9 14:00-14:30 Room 428

Michał Kijaczko

Wrocław University of Science and Technology, Poland

Abstract:

In this talk, I will present recent results concerning weighted inequalities in fractional Sobolev-type spaces. The weights considered are powers of the distance to the boundary of the domain or any flat submanifold. This will include, among others, weighted Hardy inequalities with sharp constants for Gagliardo and Triebel-Lizorkin seminorms and related inequalities with remainder terms, such as fractional Hardy-Sobolev-Maz'ya inequality. Criticality of some Hardy weights will be discussed.

Liouville theorems for left-invariant PDEs via right-invariant derivatives

Schedule: July 9 9:30-10:00 Room 428

Alessia Kogoj

University of Urbino, Italy

Abstract:

It is well known that a harmonic function with finite energy must be constant. We show how this result can be extended to partial differential operators that are left-invariant with respect to a Lie group law on $\mathbb{R}^n$.

Stability with explicit constants for reverse Sobolev inequalities on the sphere

Schedule: July 9 17:30-18:00 Room 428

Tobias K\"onig

Goethe University Frankfurt, Germany

Abstract:

For $s - \frac{n}{2} \in (0, 1) \cup (1, 2)$, a reverse-type Sobolev inequality of order $2s$ holds on the sphere $\mathbb{S}^n$. In my talk, I will discuss recent results on the quantitative stability of this inequality. Implementing the classical proof strategy by Bianchi and Egnell is non-trivial here because the underlying operator A_{2s} is not positive definite when $s > \frac{n}{2}$. Remarkably, the case $s - \frac{n}{2} \in (1, 2)$ constitutes the first example of a Sobolev-type stability inequality (i) whose best constant is explicit and (ii) which does not admit an optimizer.

On the superposition and the Phragmén-Lindelöf principles for the p -Laplacian

Schedule: July 9 8:30-9:00 Room 428

Pier Domenico Lamberti

University of Padova, Italy

Co-Author(s): Vitaly Moroz

Abstract:

We prove a Phragmén-Lindelöf type comparison principle for equations driven by the p -Laplacian on exterior domains, in the presence of a negative potential and for $p \geq 2$. As a consequence, we obtain upper and lower bounds for subsolutions and supersolutions in the setting of Hardy-type potentials. The argument is based on a new superposition principle for the p -Laplacian. The results are part of a joint work with Vitaly Moroz.

Vectorial Kato inequality for p -harmonic maps

Schedule: July 9 15:30-16:00 Room 428

Katarzyna Mazowiecka

University of Warsaw, Poland

Co-Author(s): Andreas Gastel, Michał Miskiewicz, Patryk Tokarczuk

Abstract:

We derive the sharp vectorial Kato inequality for p -harmonic mappings. Surprisingly, the optimal constant differs from the one obtained for scalar valued p -harmonic functions. As an application we show how Kato-type inequalities can be used to deduce regularity for p -harmonic maps from a three dimensional ball to a three dimensional sphere. Based on joint works with Andreas Gastel, Michał Miskiewicz, and Patryk Tokarczuk.

Lieb-Thirring interpolation inequality and applications to systems of nonlinear Schrödinger equations

Schedule: July 9 17:00-17:30 Room 428

Phuoc Tai Nguyen

Masaryk University, Czech Rep

Co-Author(s): Phuoc-Tai Nguyen

Abstract:

In this talk, I will discuss the existence of finite-rank operators for an interpolation version of the Lieb-Thirring inequality in the mass-supercritical case. Then I will apply this result to study global existence and finite-time blow-up for systems of nonlinear Schrödinger equations.

Symmetry of fractional Neumann eigenfunctions in the ball

Schedule: July 9 16:30-17:00 Room 428

Enea Parini

Aix Marseille Université, France

Co-Author(s): Vladimir Bobkov

Abstract:

We investigate symmetry properties of the first nontrivial eigenfunctions of the fractional Laplacian $(-\Delta)^s$, where $s \in (0, 1)$, in an N -dimensional ball with nonlocal Neumann boundary conditions. By means of a spectral stability result, we prove that, when s is sufficiently close to 1, the eigenspace associated to the first nontrivial eigenvalue is generated by N antisymmetric eigenfunctions with exactly two nodal domains in the ball. This is a joint work with Vladimir Bobkov (Ufa, Russia).

Semilinear Schrödinger equations with critical Hardy potentials

Schedule: July 9 15:00-15:30 Room 428

Miltiadis Paschalis

National and Kapodistrian University of Athens, Greece

Co-Author(s): Konstantinos Gkikas; Miltiadis Paschalis

Abstract:

Let $\Omega \subset \mathbb{R}^N$ ($N \geq 3$) be a bounded C^2 domain and $\Sigma \subset \partial\Omega$ be a compact C^2 submanifold of dimension k . Denote the distance from Σ by d_Σ . In this paper, we study positive solutions of the equation $(*) \quad -\Delta u - \mu u/d_\Sigma^2 = g(u, |\nabla u|)$ in Ω , where $\mu \leq \left(\frac{N-k}{2}\right)^2$ and the source term $g : \mathbb{R} \times \mathbb{R}_+ \rightarrow \mathbb{R}_+$ is continuous and non-decreasing in its arguments with $g(0, 0) = 0$. In particular, we prove the existence of solutions of $(*)$ with boundary measure data $u = \nu$ in the case g satisfies some subcriticality conditions that always ensure the existence of solutions, provided that the total mass of ν is small. This presentation is based on a joint work with Konstantinos Gkikas.

Davies-type Hardy inequalities on the Heisenberg group

Schedule: July 9 13:30-14:00 Room 428

Durvudkhan Suragan

Nazarbayev University, Kazakhstan

Abstract:

We present Hardy inequalities on the Heisenberg group in a form reminiscent of Davies' inequalities in the Euclidean setting. Our results have two notable features. First, they improve previously known inequalities, yielding sharper estimates. Second, we prove them without imposing any boundary regularity assumptions. We also discuss how these Davies-type Hardy inequalities can be converted into sub-Laplacian eigenvalue lower bounds. This talk is based on recent joint work with Rupert L. Frank (LMU Munich and Caltech) and Ari Laptev (Imperial College London).

The FitzHugh-Nagumo System on cylindrical surfaces: symmetrization and effective system

Schedule: July 9 18:00-18:30 Room 428

Konstantinos Tzirakis

Department of Mathematics and Applied Mathematics, University of Crete, Greece

Co-Author(s): Georgia Karali and Israel Michael Sigal

Abstract:

In this talk, I will present recent results on the FitzHugh-Nagumo (FHN) system of partial differential equations. We consider the FHN system in a more realistic geometric setting: on cylindrical surfaces of variable radii, rather than straight lines without internal geometric structure, as it has been extensively done. We show that, under some reasonable conditions, the solutions of the system are exponentially approximated by their radial averages. We also show that the radial averages are close, for very long times, to solutions of a 1-spatial-dimensional system involving the cylindrical profile: it is obtained from the standard FHN system by replacing the second-order derivative by the radial surface Laplace-Beltrami operator. This system is considerably simpler for mathematical analysis and numerical simulations. It offers an effective system for the pulse propagation. I will outline the analytical approach to obtain the above results, and, time permitting, I will discuss interesting related open problems and natural extensions of these results. The talk is based on a recent joint work with Israel Michael Sigal (University of Toronto, Canada) and Georgia Karali (NKUA, Greece).

Sharp remainder terms and stability of L_p -Poincare and Heisenberg-Pauli-Weyl inequalities with applications to spectral gaps

Schedule: July 9 9:00-9:30 Room 428

Nurgissa Yessirkegenov

KIMEP University and Institute of Mathematics and Mathematical Modeling, Kazakhstan

Abstract:

This talk is devoted to our recent results on sharp remainder terms for weighted Hardy-Poincare type inequalities, including the case of general non-radial weights and explicit sharp constants. As an application of this framework, we derive sharp remainder formulae for the L_p -Poincare inequality and the L_p -Heisenberg-Pauli-Weyl inequality. If time permits, we will further discuss applications to stability, spectral gap problems, and nonlinear parabolic partial differential equations.

Special Session 81 : Analytic and numerical progress in complex fluids and related PDE models

Organizer(s): Xinyu Cheng , Shijie Dong , Tongou Yang

Introduction: This session will focus on cutting-edge topics and recent developments in nonlinear PDEs related to fluid dynamics, mathematical biology, nonlinear waves and other related fields. In particular it will focus on global existence, parameter stability (including vanishing viscosity/damping limit), free boundary problems, scattering, structure preserving numerical methods etc. for Navier-Stokes equations, the Oldroyd-B model, Klein-Gordon equations and many other related nonlinear models. Open problems in these interesting areas will be discussed.

Global current-vortex sheets in the two-dimensional ideal incompressible MHD

Schedule: July 10 8:00-8:30 Room 434

Yuan Cai

Fudan University, Peoples Rep of China

Co-Author(s): Zhen Lei

Abstract:

The magnetohydrodynamic current-vortex sheet is a free boundary problem involving a moving free surface separating two plasma regions. We show the global nonlinear stability of current-vortex sheet in the two dimensional ideal incompressible magnetohydrodynamics under the strong horizontal background magnetic field. This appears to be the first result on the global solutions of the free boundary problems for the ideal (inviscid and non-resistive) incompressible rotational fluids. The strong magnetic field plays a crucial role in the global in time stabilization effect. The proof relies on the understanding of the interplay between the dynamics of the fluids inside the domain and on the free interface, a design of multiple-level energy estimates with different weights, and the inherent structures of the problem. This is based on the joint work with Professor Zhen Lei.

Flux Globalization Based Well-Balanced Path-Conservative Central-Upwind Scheme for Shallow Water Equations

Schedule: July 10 15:00-15:30 Room 434

Yangyang CAO

Shenzhen MSU-BIT University, Peoples Rep of China

Abstract:

In this work, we propose flux globalization based well-balanced path-conservative central-upwind schemes for several shallow water models. We focus on development of the well-balanced schemes capable of exactly preserving quite complicated steady-state solutions the studied systems admit when the bottom topography is discontinuous. In such cases, nonconservative product terms naturally appear and they require a special treatment. To this end, we incorporate the nonconservative product terms into the global fluxes using the path-conservative technique implemented within a framework of simple---yet highly accurate and robust---Riemann-problem-solver-free central-upwind schemes. This results in new flux globalization based central-upwind schemes, which are more accurate than their existing counterparts. The advantages of the proposed schemes are demonstrated on a number of numerical examples.

The local regularity theory for the Stokes and Navier-Stokes equations near the curved boundary

Schedule: July 10 11:00-11:30 Room 434

Hui Chen

Zhejiang University of Science and Technology, Peoples Rep of China

Co-Author(s): Hui Chen, Su Liang, Tai-Peng Tsai

Abstract:

In this talk, we study local regularity of the solutions to the Stokes equations near the curved boundary under no-slip and slip boundary conditions. As an application, we propose a new definition of boundary regular points for the incompressible Navier-Stokes equations that guarantees higher spatial regularity.

Parameter-limit preserving low-regularity method in fluid models: analytic and numerical results

Schedule: July 10 11:30-12:00 Room 434

Xinyu Cheng

Fudan University, Peoples Rep of China

Abstract:

Among the study of PDEs arising from fluid dynamics and material sciences, parameter stability including vanishing viscosity/damping limits is a very interesting research topic. Indeed, it is deeply related to boundary layers, perturbation theory, and many other areas. However, parameter-limit structure is not always preserved in numerical simulations. On the other hand, solutions with low regularity play an important role in the study of fluid PDEs and are deeply connected to the well-known Onsager conjecture. Therefore, computing such low-regularity solutions while preserving parameter stability is of great significance. In this talk, we will discuss some recent progress in the structure-preserving methods for low-regularity problems arising from fluid models, supported by both analytical and numerical results.

Scattering and energy cascade for the 2D Klein-Gordon-Zakharov

Schedule: July 10 17:00-17:30 Room 434

Shijie Dong

Southern University of Science and Technology, Peoples Rep of China

Co-Author(s): Zihua Guo and Kuijie Li

Abstract:

We study the Klein-Gordon--Zakharov system in two spatial dimensions, an important model in plasma physics. For small, smooth, and spatially localized initial data, we establish the global existence of solutions and characterize their sharp long-time behavior, including sharp time decay, scattering, and growth of Sobolev norms. This is joint with Prof. Zihua Guo and Prof. Kuijie Li.

Global well-posedness and stability for the non-resistive magnetohydrodynamical systems

Schedule: July 10 14:00-14:30 Room 434

Bin Han

Donghua University, Peoples Rep of China

Abstract:

In this talk, we consider the global existence results on the compressible and incompressible magnetohydrodynamics without magnetic diffusivity. The absence of dissipation in the magnetic field and density leads to significant analytical difficulties. To overcome this problem, we introduce the deformation gradient, which reveals an effective dissipative structure relating the magnetic field to the inverse deformation tensor. By developing time-weighted energy estimates, we establish the global well-posedness of classical solutions with small initial data around equilibrium

On the differentiability of local times of $(1 + \beta)$ -stable super-Brownian motion

Schedule: July 10 14:30-15:00 Room 434

Jieliang Hong

Southern University of Science and Technology, Peoples Rep of China

Co-Author(s): Ziyi Chen

Abstract:

We consider the local times of $(1 + \beta)$ -stable super-Brownian motion with $0 < \beta < 1$. It is known from Sugitani (J. Math. Soc. Japan, 41(3), 437--462, 1989) that for $\beta = 1$, the local time is differentiable in $d = 1$. For $0 < \beta < 1$, Mytnik and Perkins (Ann. Probab., 31(3), 1413--1440, 2003) proved that the local time, denoted by $L(t, x)$, is jointly continuous in $d = 1$ while it is locally unbounded in x in $d \geq 2$ where it exists. This paper strengthens the results of Mytnik and Perkins for $d = 1$ by showing that the local time $L(t, x)$ is continuously differentiable in the spatial parameter x . Moreover, we give a representation of the spatial derivative, denoted by $\frac{\partial}{\partial x} L(t, x)$, and further prove that the derivative is locally γ -Hölder continuous in x with any index $\gamma \in (0, \frac{\beta}{1+\beta})$.

On self-similar finite-time blowups of the incompressible Euler equations and related models

Schedule: July 10 8:30-9:00 Room 434

De Huang

Peking University, Peoples Rep of China

Abstract:

It remains an open problem whether the 3D incompressible Euler equations can develop finite-time singularity from smooth initial data in the whole space. In this talk, I will review some most recent results on finite-time blowups mostly with self-similar features, divided into two parts. In the first part, I will talk about traditional self-similar finite-time blowup and the dynamic rescaling method for establishing asymptotically self-similar finite-time blowup. In the second part, I will talk about recent findings on potential self-similar finite-time blowups of the 3D Euler equations with multi-scale features, which are closely related to traveling wave solutions and provide a new approach towards Euler singularity.

Morawetz type estimates for wave/Schrödinger equations and its applications

Schedule: July 10 9:30-10:00 Room 434

Ning-An Lai

Zhejiang Normal University, Peoples Rep of China

Abstract:

In this talk, I will talk about some Morawetz type estimates for the wave/Schrödinger equations. And some related results will be discussed.

Asymptotic behavior for the Maxwell-Dirac system in Lorenz and Coulomb gauges

Schedule: July 10 13:30-14:00 Room 434

Kiyeon Lee

KAIST, Korea

Co-Author(s): Yonggeun Cho

Abstract:

In this talk, I will present the nonlinear scattering results for the Maxwell-Dirac system in the Lorenz and Coulomb gauges. In the Lorenz gauge, we obtained the nonlinear scattering results in Cho-Lee (\cite{1}). Using this approach, we also prove nonlinear scattering in the Coulomb gauge. Although the Coulomb gauge lacks Lorentz invariance, it allows the elliptic nature of the scalar potential to be exploited. We introduce a spinorial null structure to overcome the lack of Lorentz invariance and to obtain the desired asymptotic behavior. Moreover, the vector field method combined with various resonance analyses adapted to the Coulomb gauge will be discussed.

On the steady Navier-Stokes equations in a system of channels: existence, uniqueness and rigidity

Schedule: July 10 9:00-9:30 Room 434

Xiao Ren

Center for Applied Mathematics, Fudan University, Peoples Rep of China

Co-Author(s): Giovanni P. Galdi, Filippo Gazzola, Mikhail Korobkov, Gianmarco Sperone

Abstract:

The steady motion of a viscous incompressible fluid in a junction of unbounded channels is modeled through the Navier-Stokes equations under inhomogeneous Dirichlet boundary conditions. In contrast to many previous works, the domain is not assumed to be simply-connected and the fluxes are not assumed to be small. In this very general setting, we prove the existence of a solution with a uniformly bounded Dirichlet integral in every compact subset. This is a generalization of the classical Ladyzhenskaya-Solonnikov result obtained under the additional assumption of zero boundary conditions. For small data of the problem we prove the unique solvability and attainability of Couette-Poiseuille flows at infinity. Further, by extending and refining an approach initially introduced by J.B. McLeod, we prove the rigidity of a generic class of Couette-Poiseuille flows, without any restriction on the size of the flux or the periodicity of perturbation. Based on joint works with Giovanni P. Galdi, Filippo Gazzola, Mikhail Korobkov and Gianmarco Sperone.

Neural network methods for non-smooth PDE-constrained optimization

Schedule: July 10 15:30-16:00 Room 434

Yongcun Song

Nanyang Technological University, Singapore

Abstract:

We present neural network methods for solving non-smooth PDE-constrained optimization problems. Our investigation focuses on three challenging categories: (1) optimization with non-smooth regularization, (2) optimal control of PDEs involving interfaces, and (3) optimal control of elliptic variational inequalities. For each category, we develop tailored neural network algorithms that exploit the specific mathematical structure of the underlying problem. The principal advantages of our methods are that they are mesh-free, thus avoiding grid generation challenges; computationally scalable to high dimensions and complex domains; and straightforward to implement. Extensive numerical experiments demonstrate their computational efficiency and accuracy on benchmark problems

Mixing flow and its applications

Schedule: July 10 12:00-12:30 Room 434

Xiaoqian Xu

Duke Kunshan University, Peoples Rep of China

Abstract:

In the study of incompressible fluid, one fundamental phenomenon that arises in a wide variety of applications is dissipation enhancement by so-called mixing flow. In this talk, I will give a brief introduction to the idea of mixing flow and examples of such flows. In addition, I will also discuss the un-mixing property of the diffusion process.

Decoupling for degenerate hypersurfaces

Schedule: July 10 16:30-17:00 Room 434

Tongou Yang

Southern University of Science and Technology, Peoples Rep of China

Co-Author(s): Jianhui Li

Abstract:

The Fourier decoupling theory developed by Bourgain and Demeter in 2015 has found its applications in harmonic analysis as well as dispersive PDEs. Their proof relies heavily on the nonzero curvature property of the hypersurfaces. We seek to generalise decoupling inequalities to smooth hypersurfaces, by using different partitioning rectangles in the Fourier space.

Boundary Regularity and Global Classical Solution of Dynamic Prandtl Equation

Schedule: July 10 10:30-11:00 Room 434

Cheng Yuan

School of Mathematical Sciences, Fudan University, Peoples Rep of China

Co-Author(s): Hao Jia, Zhen Lei

Abstract:

In this talk, I will present the boundary regularity theory and the global well-posedness of regular classical solutions on the dynamic Prandtl equations. To begin, we first establish the up-to-boundary regularity theory for the dynamic Prandtl system. The main obstacle lies in the lack of an explicit expression for the fundamental solution of a certain ultra-parabolic operator in the half-space. Our key strategies in overcoming this regularity issue include identifying the collaboration mechanism between diffusion and transport for a simplified operator, and then combining Fourier analysis, enhanced dissipation theory, and iterative methods to establish a series of hypoelliptic estimates for linear and quasilinear equations. By combining the established boundary regularity with the presented local theory, we also prove the global--in-- t, x well-posedness of regular classical solutions for the Prandtl system. This is joint work with Prof. Hao Jia (University of Minnesota) and Prof. Zhen Lei (Fudan University).

Special Session 82 : Dissipative Systems and Applications

Organizer(s): Lourdes Tello , Wenxian Shen

Introduction: Dissipative Systems and Applications. Dissipative systems are fundamental in the understanding and modeling of a large number of phenomena that arise in Science and Engineering. In this session we share research on dissipative models in Differential Equations approached from different points of view by researchers who emphasize different aspects. Differential equations (PDES and ODES) are nowadays a very useful tool for both theoretical and applied analysis. Aspects such as stability, bifurcation with respect to a certain parameter, asymptotic behavior, existence of periodic or stationary solutions and numerical approximation of solutions to nonlinear models will be treated.

A two-layer heterogeneous green roof mathematical model.

Schedule: July 7 18:00-18:30 Room 427

Ruben De La Cruz

Universidad Politecnica de Madrid, Spain

Abstract:

We propose a mathematical model to analyze the thermal behavior of extensive green roofs. This model is based on an energy balance for buildings with vegetation cover. The two-layer model includes a vegetation layer and a substrate layer, as well as the energy exchange between them. The unknowns in this problem are the temperatures of each layer which are described by a coupled system of two parabolic partial differential equations with Robin boundary conditions. One of the main feedback mechanisms is evapotranspiration, that is, the combined process of plant transpiration and substrate evaporation. The model takes into account the latent heat of fusion, due to the phase change of liquid water to ice or vice versa in the porous substrate. The modeling involves multivalued terms, and regularizing maximal monotone graphs is crucial to the mathematical treatment. We approximate the solutions to the parabolic system of partial differential equations using the finite volume method with the Weighted Essentially Non-Oscillatory (WENO) technique for spatial reconstruction and the third-order SSPRK method for time integration. This is a joint work with L.Tello.

Effects of temporal variations on wave speeds of bistable traveling waves for Lotka-Volterra competition systems

Schedule: July 6 18:30-19:00 Room 427

Weiwei Ding

South China Normal University, Peoples Rep of China

Co-Author(s): Zhanghua Liang

Abstract:

This talk is concerned with the bistable traveling waves for two-species Lotka-Volterra competition systems in time periodic environments. We focus especially on the influence of the temporal period, with existence results established for both small and large periods. We also show the existence of, and derive explicit formulas for, the limiting speeds as the period tends to zero or infinity, and provide estimates for the corresponding rates of convergence. Furthermore, we analyze the sign of wave speed. Based on our explicit formulas for the limiting speeds, we construct an example in which the sign of wave speed changes with the temporal period. This example reveals that temporal variations can significantly influence competition outcomes, enabling different species to become dominant under different periods.

Precise propagation dynamics of the nonlocal KPP free boundary problem with nonsymmetric kernels

Schedule: July 6 16:30-17:00 Room 427

Yihong Du

University of New England (Australia), Australia

Co-Author(s): Xiangdong Fang, Wenjie Ni

Abstract:

Sharp estimates of the spreading rates for the nonlocal KPP free boundary problem with symmetric kernels have been established by Du and Ni (Math Ann 2024, JEMS 2025). In this talk we report some recent progresses on the precise propagation profile of this model with nonsymmetric kernels, where significant differences arise. These include sharp conditions governing linear spreading (spreading with finite speed) and accelerated spreading (spreading with infinite speed), and precise rates of spreading.

Propagation dynamics on hexagonal lattice

Schedule: July 6 18:00-18:30 Room 427

Jian Fang

Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Yijun Lou, Yifei Li, Jian Wang

Abstract:

We investigate the propagation dynamics of discretized reaction-diffusion equations in hexagonal lattice. From both analytical and numerical viewpoint we identify some angular dependencies on the speeds of traveling waves.

Modeling Density-Dependent Emigration Between Two Competing Species of Tribolium: Part II -- Results

Schedule: July 6 13:30-14:00 Room 427

Jerome Goddard II

Auburn University Montgomery, USA

Co-Author(s): J. T. Cronin & R. Shivaji

Abstract:

We present experimental and modeling results for a two-species *Tribolium* system designed to investigate how density-dependent emigration influences long-term population outcomes. Using data from 12-generation replicate microcosm experiments, together with a parameterized reaction diffusion Lotka-Volterra model, we study the effects of intraspecific density, competitor density, patch size, and permeability on emigration and persistence. By propagating parameter variability through the model, we obtain probabilistic predictions for long-term steady states and compare these predictions with persistence patterns observed in the microcosms. The results suggest that intraspecific density plays a leading role in shaping emigration behavior, while habitat structure also substantially affects long-term outcomes. This talk emphasizes the main qualitative and probabilistic results, along with the extent to which the model captures experimentally observed persistence and exclusion patterns.

Dynamics of an SIS epidemic model with population outflow on the boundary

Schedule: July 6 14:00-14:30 Room 427

Yu Jin

University of Nebraska-Lincoln, USA

Co-Author(s): Yaru Hu, Jinfeng Wang

Abstract:

We consider a reaction-diffusion SIS epidemic model with population outflow on the boundary in a spatially heterogeneous environment. The main feature of our model is that the total population is variable. We introduce a basic reproduction number and use it to establish threshold-type results on the global dynamics. In particular, our highlight is that the introduction of population outflow on the boundary tends to suppress the persistence of the disease to some extent.

Measure-Based Differential Operators and Equations with Distributed Delay

Schedule: July 7 14:30-15:00 Room 427

Marek Kryspin

Wroclaw University of Science and Technology, Poland

Abstract:

We present results on existence and uniqueness, mild solutions, and a measure-based integration approach for a broad class of differential and pseudo-differential equations with distributional delay on $[-1, 0]$. We consider the differential problem
$$x'(t) = \int_{[-1, 0]} x(t+s) \, d\mu(s; t),$$
 or, more generally,
$$(Dx)(t) = \int_{[-1, 0]} x(t+s) \, d\mu(s; t)$$
 with an appropriate initial condition $x|_{[-1, 0]}$. Here D is the pseudo-differential operator defined for some signed measure α via a generalized Newton-Leibniz identity
$$x(t) - x(s) = \int_{[s, t]} (Dx)(\xi) \, d\alpha(\xi).$$
 For a given measure α , we define the function space on which the operator D is well-defined. We also present random versions of these equations, as well as models based on partial differential equations, which appear to be more suitable for applications in biology and mathematical ecology. Such problems provide a starting point for the study of random dynamical systems generated by the associated solution operator

The energy (and its dissipation) in the chemotaxis-consumption system

Schedule: July 6 15:30-16:00 Room 427

Johannes Lankeit

Leibniz University Hannover, Germany

Abstract:

With a new look at the (quasi-)energy in the basic chemotaxis-consumption system and the corresponding dissipation terms, we treat global existence of weak solutions, their eventual smoothness and large-time asymptotics. (This talk is based on joint work with M. Winkler.)

Can disease invasion match population expansion in a time-periodic SI free boundary model?

Schedule: July 6 17:30-18:00 Room 427

Yijun Lou

The Hong Kong Polytechnic University, Hong Kong

Co-Author(s): Yijie Zha

Abstract:

This talk presents the invasion dynamics of a time-periodic reaction-diffusion SI model with a free boundary. Employing the theory of time-varying domains and internally chain transitive sets, we rigorously establish a spreading-vanishing dichotomy for both the host population and the disease, and derive sharp criteria characterizing the conditions for spreading and vanishing. Furthermore, in the spreading scenario, we determine the asymptotic speed of the expanding population front, and compare it with the spreading speed of disease invasion. Various scenarios are presented to examine whether the speed of disease invasion can match that of host expansion, with corresponding sharp conditions provided. Further numerical simulations will be presented to validate theoretical results.

A differential equation approach to the study of random SIR models with vital dynamics and time-varying vaccination rate

Schedule: July 6 15:00-15:30 Room 427

Javier L\opez-de-la-Cruz

Universidad Polit\ecnica de Madrid, Spain

Abstract:

Epidemics have profoundly affected humanity throughout history, causing not only severe human losses but also major social and economic disruptions. Many infectious diseases that have produced large outbreaks in the past still persist today, while new ones continue to emerge. For this reason, mathematical models play a crucial role in understanding disease dynamics and in designing strategies to control their spread. One of the fundamental models in mathematical epidemiology is the classical SIR model introduced by Kermack and McKendrick in 1927. This compartmental model divides the population into three groups: susceptible, infected, and recovered individuals. Despite its importance, the classical SIR framework relies on several simplifying assumptions, such as constant population size, deterministic transmission, and the absence of vaccination, which limit its applicability to real epidemic scenarios. In this talk, we study more realistic epidemic models obtained by extending the classical SIR framework. In particular, we incorporate demographic effects and time-dependent vaccination, and we also introduce randomness in key parameters, such as the transmission rate, to capture the inherent variability observed in real epidemics. Using systems of differential equations, we analyze the resulting models and investigate the conditions under which the disease either dies out or persists in the population. Finally, we complement the theoretical results with numerical simulations and discuss their epidemiological interpretation.

Time-periodic carrying simplex for a competitive system of Carath\eodory ODEs

Schedule: July 7 14:00-14:30 Room 427

Janusz Mierczy\lski

Wroc\aw University of Science and Technology, Poland

Co-Author(s): Stephen Baigent

Abstract:

Carrying simplices (CSs) are a powerful tool in the investigation of competitive systems of ordinary differential equations (ODEs), as well as their time-discrete counterparts (both give rise to dissipative dynamical systems). Roughly speaking, they are unordered invariant sets, Lipschitz homeomorphic to the standard probability simplex, and forming the joint boundary between the repulsion sets of the origin and the point at infinity. We prove the existence and investigate properties of time-periodic family of CSs for totally competitive time-periodic systems of ODEs where the right-hand sides satisfy the Carath\eodory-type conditions. We utilize an existence theory of CSs for retrotone time-discrete dynamical systems, developed earlier by us, where the CS is defined as the joint limit of monotone sequences of images of a given set. This is a joint work with Stephen Baigent, UCL.

A competition model with nonlocal diffusion and free boundaries

Schedule: July 6 17:00-17:30 Room 427

Wenjie ni

University of New England, Australia

Co-Author(s): Yihong Du and Linfei Shi

Abstract:

We investigate the long-time dynamics of a two-species competition model of Lotka Volterra type with nonlocal diffusions. In this setting, a native species occupies the whole environment, while an invading species spreads with two moving fronts, forming a habitat that expands over time. The system is modeled by a reaction diffusion equation with free boundaries, and the key question is whether the invaded region eventually remains bounded or grows without limit.

Existence Results for Elliptic and Parabolic Bernoulli Free Boundary Problems with Radon Measure Data

Schedule: July 7 17:30-18:00 Room 427

Juan Francisco JF Padial

Depto Matemática Aplicada. Universidad Politécnica de Madrid, Spain

Abstract:

The classical semilinear problem

$$-\Delta u = F(x, u) \quad \text{in } \Omega \subset \mathbb{R}^N,$$

has been widely studied when the nonlinearity F is a given function. However, several models in Physics and Mechanics naturally lead to equations of the form $-\Delta u = \mu(x, u)$, where μ is a Radon measure depending on the solution itself. A relevant example is the interior Bernoulli free boundary problem, in which the measure is supported on the unknown interface. In the elliptic setting, Diaz-Padial-Rakotoson (2007) developed an existence theory for such problems, showing that the Bernoulli condition can be expressed through the identity

$$\int_{\Omega} |\nabla u|^{p-2} \nabla u \cdot \nabla \varphi \, dx = \int_{\partial(u^{-1}(1))} q \varphi \, d\mathcal{H}_{N-1},$$

highlighting the role of the measure as a Lagrange multiplier on the free boundary. This work extends that framework to the evolutionary setting. A semi-implicit time discretization transforms the parabolic problem into a sequence of elliptic problems of the previous type. This scheme can be viewed as a backward Euler approximation of the parabolic Bernoulli problem, where the regularization around the Bernoulli level set yields diffuse approximations of the measure. Passing to the limit provides a time-dependent Radon measure supported on the evolving free boundary. Combining this approach with a Ghoussoub-Preiss mountain pass argument yields existence of weak solutions to the evolutionary Bernoulli free boundary problem.

Local or non local properties of the solutions of some elliptic and parabolic PDE's

Schedule: July 7 17:00-17:30 Room 427

Maria Michaela MM Porzio

Sapienza University of Rome, Italy

Abstract:

In this talk we discuss the influence of the data on some properties of the solutions to equations of Leray-Lions type in the elliptic case together with the evolutionary one. Significant cases are the heat equation and the degenerate p -Laplacian equation (slow diffusion). We show that there are properties which are determined by the local properties of the data and some other properties which have not a local nature. In particular, we study the impact of the data on the sign of the solutions in all the domain or in a subset with non null measure.

DYNAMICS AND SMOOTH GLOBAL ATTRACTOR FOR A THERMOELASTIC GREEN-LINDSAY PLATE

Schedule: July 7 15:00-15:30 Room 427

Paulo Nicanor Seminario Huertas

Polytechnic University of Madrid, Spain

Abstract:

In this talk, we investigate the asymptotic dynamics of a thermoelastic plate of Green-Lindsay type, a model characterized by two relaxation times that exhibits finite-speed heat waves. Recently, the well-posedness and exponential stability of the homogeneous linear problem were established, although it remained an open question whether the domain of the semigroup generator is compactly embedded into the energy space. We address this challenge by studying the system in the presence of a nonlinear foundation. By overcoming the technical difficulties associated with the lack of compact embedding, we prove the existence of a finite-dimensional smooth global attractor for the associated dynamical system.

Modeling Post-Infection Mortality: A Tale of Two Incidence Functions

Schedule: July 6 14:30-15:00 Room 427

Zhisheng Shuai

University of Central Florida, USA

Abstract:

Post-infection mortality is an important yet often overlooked factor in epidemiological modeling, as it directly influences both disease prevalence and long-term population structure. In this work, we revisit and analyze a compartmental model that explicitly incorporates post-infection mortality along with partial immunity, and we investigate how disease outcomes depend on the choice of incidence function. Under mass-action incidence, the inclusion of post-infection mortality can generate complex dynamics, including bifurcations that lead to recurrent outbreaks. In contrast, when standard incidence is used, such oscillatory behavior is greatly reduced or eliminated, and the system typically converges to a stable endemic state. Our results show that modeling post-infection mortality in combination with different transmission assumptions leads to markedly different qualitative and quantitative outcomes, underscoring its significance for understanding persistent infections and for guiding more realistic epidemiological predictions.

On the Uniqueness and Multiplicity of positive solutions to an elliptic spectral problem with concave and convex nonlinearity

Schedule: July 7 16:30-17:00 Room 427

Peter Takac

University of Rostock, Germany

Co-Author(s): J. Benedikt, P. Girg, and L. Kotrla

Abstract:

We will discuss the question of **existence** and **multiplicity** of positive solutions to the semilinear elliptic Dirichlet problem (1)

$$-\Delta u = \lambda u(x)^{q(x)-1} + f(x, u(x)) \quad \text{for } x \in \Omega; \quad u = 0 \quad \text{on } \partial\Omega,$$

where $\Omega \subset \mathbf{R}^N$ is a bounded domain with the boundary of class $C^{1,\alpha}$, $\lambda \in \mathbf{R}^1$ a spectral parameter, and $f(x, u) = |u|^{r-1}u$ is a **signed r -power** ($r > 0$) of the unknown function of (a positive variable) $u \in (0, \infty)$ which depends on the point $x \in \Omega$; $r = q(x) - 1$, for instance. We will briefly present basic methods for treating the semilinear problem (1) with a **convex** and **concave** non-linear reaction $f(x, \cdot): s \mapsto |s|^{q(x)-2}s: \mathbf{R}_+^1 \subset \mathbf{R}^1 \rightarrow \mathbf{R}^1$ which (for $s \geq 0$) is **convex** in a nonempty open subset $\Omega_+ \stackrel{\text{def}}{=} \{x \in \Omega: q(x) > 2\}$ and **concave** in another nonempty open subset $\Omega_- \stackrel{\text{def}}{=} \{x \in \Omega: q(x) < 2\}$ of a bounded domain $\Omega \subset \mathbf{R}^N$. Here, $\lambda \in \mathbf{R}_+^1$ is a non-negative spectral parameter which decides about the existence and multiplicity of positive weak solutions (at least two) to problem (1) in case we take $f \equiv 0$. Our main contribution is a method how to handle the interplay between convex and concave non-linearities in two disjoint nonempty open subsets of a domain Ω (connected in $\mathbf{R}^N$), as opposed to the classical works assuming a non-linearity $f(s)$ being concave for small values of $s \in \mathbf{R}_+^1$ and convex for large $s \in \mathbf{R}_+^1$, uniformly in Ω . Finally, if time permits, we will discuss also the classical question of **uniqueness** for a related problem with the $p(x)$ -Laplacian provided $q(x) \leq \text{const}_1 < \text{const}_2 \leq p(x)$ holds for all $x \in \Omega$, and for $p(x) \equiv 2$ the **multiplicity** of large solution branches bifurcating from infinity as $\lambda \searrow 0+$.

On a Global Climate Model with Nonlinear Diffusion and non-monotone Coalbedo.

Schedule: July 7 18:30-19:00 Room 427

Lourdes Tello

Universidad Politecnica de Madrid, Spain

Abstract:

We study a climate model based on a global energy balance, formulated through a parabolic equation. The space domain of this equation is a manifold that simulates the Earth's surface. The diffusion operator is nonlinear. The model includes the effect of Coalbedo, which is one of the mean temperature feedbacks. Coalbedo is modelled as a multivalued function. We extend some mathematical results proven for maximal monotone Coalbedo to cases where the Coalbedo is not monotone with respect to temperature. Furthermore, we analyse the number of steady states according to one parameter.

Typical behavior of differentially positive systems on a globally orderable Riemannian manifold

Schedule: July 7 15:30-16:00 Room 427

Yi Wang

University of Science and Technology of China, Peoples Rep of China

Co-Author(s): Lin Niu

Abstract:

Differentially positive systems are nonlinear systems whose linearization along trajectories preserves a cone field on a smooth Riemannian manifold. The structures of cone field come from general relativity and Lie theory. In this talk, we will show that almost all (in both topological and measure-theoretic sense) orbits are convergent to certain single equilibrium. This solved a reduced version of Forni-Sepulchre's conjecture in 2016 for globally orderable manifolds.

Global dynamics of reaction-diffusion systems with a time-varying domain

Schedule: July 7 13:30-14:00 Room 427

Xiaoqiang Zhao

Memorial University of Newfoundland, Canada

Co-Author(s): King-Yeung Lam, Xiao-Qiang Zhao and Min Zhu

Abstract:

In this talk, I will report our recent research on the global dynamics of a large class of reaction-diffusion systems with a time-varying domain. By appealing to the theories of asymptotically autonomous and periodic semiflows, we establish the threshold type results on the long-time behavior of solutions for such a system in the cases of asymptotically bounded and periodic domains, respectively. To investigate the model system in the case of asymptotically unbounded domain, we first prove the global attractivity for nonautonomous reaction-diffusion systems with asymptotically vanishing diffusion coefficients via the method of sub- and super-solutions, and then use the comparison arguments to obtain the threshold dynamics. We also apply these analytical results to a reaction-diffusion model of Dengue fever transmission to study the effect of time-varying domain on the basic reproduction number.

Special Session 83 : New Aspects of Mathematical Modeling and Analysis in Materials Science

Organizer(s): Toyohiko Aiki , Adrian Muntean

Introduction: Expectations for advancements in materials science continue to rise. In response, the field has become increasingly effective, driving the development of innovative new products. The enhanced functionality of these materials relies heavily on a robust experimental understanding of microstructural evolution, as well as an equally strong capability to mathematically model the underlying physics and make accurate predictions. This section aims to advance mathematical methodologies for modeling new materials with complex microstructures. In addition to addressing multiscale problems, we will explore mathematical analysis and simulation techniques for tackling domain-changing phenomena - such as the deformation of elastic materials - and cross-diffusion-type systems, which arise in contexts like moisture transport through porous media and charge movement in energy-harvesting materials.

Analysis of nonlinear parabolic equations via the finite volume method

Schedule: July 6 17:30-18:00 Room 812

Toyohiko Aiki

Japan Women's University, Japan

Co-Author(s): Akiko Morimura

Abstract:

The finite volume method (FVM) is well-known as the numerical techniques for partial differential equations. Particularly, since the conservation law is guaranteed locally, it is widely employed for physic-based problems. In this talk, we apply FVM to the analysis for the moisture transport in the one-dimensional porous materials. The transport process is given as the quasilinear partial differential equations of parabolic type with non-monotone boundary conditions, which poses significant mathematical challenges for establishing the existence of strong solutions, as the standard evolution equation theory is not directly applicable. To overcome these difficulties, we succeed in showing strong solvability by employing FVM. Moreover, we derive error estimates for the approximate solutions. The aims of this talk are to explain our approach and to highlight the theoretical and numerical advantages of the finite volume method for quasilinear parabolic equations accompanying the non-monotone boundary conditions.

Quasi-variational inequality for elastoplasticity with nonlinear kinematic hardening

Schedule: July 7 18:00-18:30 Room 812

Yoshiho Akagawa

Kyoto University of Education, Japan

Abstract:

Quasi-variational inequality for elastoplasticity with nonlinear kinematic hardening Abstract: We study the mathematical formulation of elastoplasticity problems with strain hardening, focusing on nonlinear kinematic hardening. The problem is formulated as a coupled system consisting of an evolution inclusion for the stress field, described by the subdifferential operator of the indicator function associated with a constraint set, and an equation of motion for the displacement field. Our model extends the Duvaut-Lions type formulation for perfect plasticity. The hardening behavior is characterized by the translation of the constraint set depending on the strain through the back-stress tensor, which represents the movement of the yield surface in the stress space. This leads to a quasivariational inequality structure where the constraint set depends on the unknown function. To prove the well-posedness, we employ a fixed-point argument. We introduce solution operators for the variational inequality and the equation of motion, respectively, and consider their composition as a mapping on a suitable function space. By establishing that this mapping is a contraction on a sufficiently small time interval, we obtain the existence and uniqueness of solutions via the Banach fixed-point theorem. The key a priori estimates then enable us to extend the local solution to the entire time interval.

Homogenization of multi-species Poisson-Nernst-Planck equations in a porous medium

Schedule: July 6 17:00-17:30 Room 812

Apratim Bhattacharya

NISER, India

Abstract:

We derive a homogenized model for the multi-species Poisson-Nernst-Planck (PNP) equations defined on a periodic porous medium. This extends the previous homogenization results for the PNP equations concerning two species. Here, the main difficulty is that the microscopic concentrations remain uniformly bounded in a space with relatively weak regularity. Therefore, the standard Aubin-Lions-Simon type compactness results for porous media, which give strong convergence of the microscopic solutions, become inapplicable in our weak setting. We overcome this problem by a new approach involving cut-off functions.

Homogenization of a Stokes-Reaction System with Evolving Microstructure

Schedule: July 6 16:30-17:00 Room 812

Michael Eden

University of Regensburg, Germany

Co-Author(s): Richard Höfer

Abstract:

We study a coupled Stokes-reaction-diffusion system posed in a non-periodically perforated domain where the size of solid ball inclusions of size $\sim \varepsilon^\alpha$ evolves through a surface reaction mechanism. We consider the scaling regime $\alpha \in (1, 3]$ for the size of the inclusions and show local-in-time well-posedness for the micro-problem via a contraction mapping argument. We then analyze the asymptotic behavior $\varepsilon \rightarrow 0$ as the microstructure size tends to zero. Depending on the scaling parameter α , we get different limiting regimes, including a critical case and subcritical regimes.

Quasi-variational inequality approach to modeling superconductivity

Schedule: July 7 16:30-17:00 Room 812

Maria Gokili

Cardinal Stefan Wyszyński University in Warsaw, Poland

Co-Author(s): Nobuyuki Kenmochi, Marek Niezgodka

Abstract:

The Maxwell equation $u_t + \nabla \times (\rho \operatorname{curl} u) = f$ is well known as a fundamental equation, where u is a magnetic field, ρ is a nonnegative function of resistivity and f is a given vector field. In this context, $\operatorname{curl} u$ stands for the current density. In some situations, it cannot exceed some critical value, which may depend on the temperature or the magnetic field u . This leads to a quasi-variational inequality form of the Maxwell equation, which should also allow us to treat the superconductivity case, when the resistivity ρ drops near zero at some critical temperature.

A threshold-type algorithm for fourth order geometric motions

Schedule: July 7 14:00-14:30 Room 812

Katsuyuki Ishii

Kobe University, Japan

Abstract:

In this talk, we are concerned with a numerical algorithm for the motion of hypersurfaces/curves by the fourth order geometric equations such as the Willmore flow equation. The algorithm we introduce here was first proposed by Bence, Merriman and Osher in 1991 to numerically compute mean curvature flows. Our algorithm is an application of theirs and we use the fourth order heat equation instead of the second order one. We present the asymptotic expansion of the solution for the fourth order heat equation and the consistency result. This talk is based on my joint work with Professors Y. Kohsaka (Kobe U.), N. Miyake (Kyushu U.) and K. Sakakibara (Kanazawa U. & RIKEN).

Morphology formation in three space dimensions for a coupled system of parabolic equations with nonlinear and nonlocal drift

Schedule: July 7 8:30-9:00 Room 812

Nicklas Jönvall

Karlstad University, Sweden

Co-Author(s): Emilio N M Cirillo, Nicklas Jönvall, Rainey Lyons, Adrian Muntean and Stela Andrea Muntean

Abstract:

We are interested in the formation of morphologies as seen in the production of organic solar cells as it arise in ternary mixtures. These mixtures consists of two active components and a passive solvent, and we are interested in facilitating their separation in space. We construct a semi-discrete finite-volume scheme that approximates the weak solution of our coupled system of parabolic partial differential equations with nonlocal and nonlinear drift posed in three space dimensions. We explore how initial conditions and model parameters affect the behavior of the solution, both with and without solvent evaporation through boundary conditions. Through numerical experiments we approximate the convergence rate of our scheme. Theoretical stability results are recovered numerically.

Behavior of the free boundary to two-phase Stefan problems for the bread baking process

Schedule: July 6 15:30-16:00 Room 812

Hana Kakiuchi

Japan Women's University, Japan

Co-Author(s): Toyohiko Aiki

Abstract:

We consider a free boundary problem for a system of two parabolic equations on the one-dimensional space interval. The problem has been proposed as a mathematical model for a baking bread process in a hot oven. In the model we assume that the region consists of crumb, crust, and the evaporation front. For the model, we add a free boundary condition obtained from the energy conservation law. The unknown functions of our problem are the position of the evaporation front, the temperature field, and the water content. For solving this problem we observed two difficulties that the growth rate of the free boundary contains the water content and the boundary condition for the water content depends on the unknown temperature at the boundary. For these issues, we can establish existence of a strong solution locally in time and its uniqueness under high regularity assumptions on the initial data. Moreover, based on analysis for stationary solutions, we present the behavior result on the free boundary in this talk. The key of the proof is that a comparison principal for the solutions holds, even if the latent heat coefficient depends on time and lacks differentiability with respect to the time variable.

On solvability of a time-fractional semilinear heat equation

Schedule: July 6 18:30-19:00 Room 812

Mizuki Kojima

Kanagawa University, Japan

Co-Author(s): Kotaro Hisa

Abstract:

We are concerned with a semilinear parabolic problem with the Caputo type fractional derivative with respect to time. The problem where the fractional derivative is replaced with the classical one can be considered as the usual parabolic problem. The main interest is to clarify the solvability when the order of derivative approaches integer.

Existence of solutions for the elastic curve model generated by the free energy depending on the curvature

Schedule: July 7 14:30-15:00 Room 812

Chiharu Kosugi

Yamaguchi University, Japan

Co-Author(s): Chiharu Kosugi, Toyohiko Aiki

Abstract:

In this talk, we consider the initial and boundary value problem for the beam equation, which is known as one mathematical model for elastic materials. As the first step in modeling, we have introduced the stress function having the singular point. In our previous results, we have proved the existence and uniqueness of weak and strong solutions. Moreover, we obtained the lower bound of the strain. This estimate guarantees that the elastic curve does not shrink to the one point. This result indicates advantage of our model. We remark that in our model, an unknown function is vector-valued function and representing the position. For this reason, we need to treat the nonlinear strain function, and we adopt the singular stress function. For the construction of a model representing the characteristics of the elastic curve, we derive the initial and boundary value problem from the free energy including the curvature. For the mathematical difficulties, we approximate the equation by adding the sixth derivative term with respect to space variable. Based on the Galerkin method and the Aubin compact theorem, we can prove the existence of weak solutions. This is a joint work with Prof. Aiki from Japan Women's University, Japan.

Asymptotic behavior of inhomogeneous damped total variation flows with time-dependent coefficients

Schedule: July 7 17:30-18:00 Room 812

Daisuke D Kubota

Graduate School of Science and Engineering, Chiba University, Japan

Co-Author(s): Daiki Mizuno, Ken Shirakawa and Naotaka Ukai

Abstract:

In this study, we consider an inhomogeneous PDE with time-dependent damping coefficients, derived as the pseudo-parabolic gradient flow of a total variation energy with perturbation. Such perturbed total variation energies arise in applications including grain boundary motion and image denoising, and their stationary points play a fundamental role in physical and engineering contexts. In our PDE, the Euler--Lagrange equation for the perturbed total variation energy appears as the associated steady-state problem. In contrast, this Euler--Lagrange equation is formulated as a singular diffusion type equation, which admits many discontinuous solutions. Hence, it involves significant analytical difficulties. The aim of this study is to establish a method for asymptotically approaching the singular Euler--Lagrange equation through a smooth framework provided by our PDE. Moreover, with time-dependent damping coefficients, this framework enables control of the rate of time evolution. Based on these, we focus on the relationship between the set of steady-state solutions and the ω -limit set of solutions to our PDE as time tends to ∞ . In particular, by analyzing the decay rate of the time-dependent damping coefficients, we show that the decay rate essentially determines the relationship between the steady-state solutions and the asymptotic behavior of solutions.

Construction of a strong solution to a one-dimensional free boundary problem via the finite volume method

Schedule: July 6 14:00-14:30 Room 812

Kota Kumazaki

Kyoto University of Education, Japan

Abstract:

This talk presents the construction of a strong solution to a one-dimensional free boundary problem modeling the penetration of a diffusing agent into rubber. The model consists of a parabolic equation describing the diffusion of the substance and an ordinary differential equation governing the motion of the free boundary. A central difficulty arises from the non-monotone boundary conditions at the moving edge, which occur because it is not known whether the concentration of the diffusing substance vanishes at the boundary. Due to this non-monotonicity, abstract evolution equation theory cannot be applied, and only weak solutions have been obtained so far. In this talk, we demonstrate that a strong solution can be constructed by employing the finite volume method, in which the spatial domain is divided into control volumes and discretized by enforcing conservation laws on each volume.

A projection approach to elastoplasticity with kinematic hardening

Schedule: July 7 9:30-10:00 Room 812

Kazunori Matsui

Tokyo University of Marine Science and Technology, Japan

Co-Author(s): Yoshiho Akagawa

Abstract:

Engineering materials such as metals exhibit elastic deformation under small loads, but may develop permanent (plastic) deformation once the load exceeds a threshold. In a variational framework, elastoplasticity can be formulated through a stress constraint of variational inequality type. Under repeated loading and unloading, the yield surface evolves due to strain hardening; one common modeling choice is kinematic hardening, where the admissible stress set translates in stress space as plastic deformation accumulates. We study an elastoplastic model with kinematic hardening in a variational inequality setting, coupled with an equation of motion including Kelvin--Voigt viscosity. A key analytical and computational difficulty is to construct solutions while respecting the stress constraint at all times. We propose a projection-based time discretization. At each time step we first compute an unconstrained trial stress and then project it onto the translated admissible set. This trial-projection strategy preserves the constraint while avoiding a nonlinear fully implicit problem, leading to a simple implementation. We prove stability of the resulting discrete solutions under appropriate norms. Moreover, these stability estimates yield existence of a solution to the original continuous coupled problem.

Mathematical analysis of a model for tuberculosis granuloma formation

Schedule: July 7 9:00-9:30 Room 812

Masaaki Mizukami

Kyoto University of Education, Japan

Co-Author(s): Mario Fuest, Johannes Lankeit, and Yuya Tanaka

Abstract:

This talk is concerned with a model for tuberculosis granuloma formation proposed by Feng (2024). In that work, Feng not only introduced the model but also analyzed the corresponding ODE system, showing that the basic reproduction number plays a crucial role in determining the qualitative behavior of solutions. In contrast, for the PDE setting, no analytical results seem to be available so far. The purpose of this talk is to analyze the PDE system and to establish global existence of solutions as well as their grow-up properties. This talk is based on joint work with Mario Fuest (Leibniz University Hannover), Johannes Lankeit (Leibniz University Hannover), and with Yuya Tanaka (Kwansei Gakuin University).

A stochastic particle-continuum model for the chemical-induced corrosion of marble

Schedule: July 7 8:00-8:30 Room 812

Adrian Muntean

Karlstad University, Sweden

Co-Author(s): Nicklas Javergard, Daniela Morale, Giulia Rui, Stefania Ugolini

Abstract:

We present a nonlocal evolution system of SDEs describing marble degradation by acid particles, coupled with ODEs for the random fields evaluating the current damage at a continuum scales. The coupling particle-continuum is done via non-local operators, while the chemical reaction is assumed to be a Poisson counting process. Strong solutions to this system were found earlier and they are unique. We illustrate numerically their behavior, and finally, we point out a couple of currently open mathematical questions mostly concerning the model averaging (periodic homogenization) and reduction.

Numerical simulations and analysis of mathematical modeling for moisture transport in porous media

Schedule: July 6 14:30-15:00 Room 812

Yusuke Murase

Meijo University, Japan

Co-Author(s): Yusuke Murase

Abstract:

In this talk, we discuss numerical simulations and analysis of mathematical modeling for moisture transport in porous media. Our model is a system of partial differential equations with free boundary motion, coupled with a second order differential equation which presents moisture transport in macro region its outer force depends upon the position of free boundary in micro region, and usual heat equation with free boundary motion its depends on the volume of moisture at the point in the macro region, which presents moisture adsorption in porous. By these dependences, we can see our model is a multi-scale model. I will show you some numerical simulations of the model of adsorption phenomena and moisture transport full model, solvability and numerical stability of approximated equations, and some related topics.

Scale size-dependence and homogenization in elasticity

Schedule: July 7 13:30-14:00 Room 812

Grigor Nika

Karlstad University, Sweden

Abstract:

Classical homogenization is insufficient for finite-sized structures as it does not account for crucial scale-size effects. We will present a thermodynamically consistent model and subsequent two-scale expansion homogenization framework for strain-gradient elasticity that derives effective models with scale-dependent homogenized coefficients. Our key result is that the homogenized mechanical properties depend not only on the micro-geometry and volume fraction but also on the absolute size of the underlying constituents. Hence, the homogenized coefficients are not constant (as in classical homogenization) but rather functions of the microstructural size. Numerical validation confirms that the homogenized coefficients converge to the classical ones as the scale-size effects become vanishingly small, providing a critical tool for designing micro-architected materials.

Derivation and Analysis of Macroscopic Models Describing Reaction and Diffusion in Porous Media

Schedule: July 6 15:00-15:30 Room 812

CHRISTOS NIKOLOPOULOS

University of the Aegean, Greece

Abstract:

The derivation and analysis of mathematical models describing diffusion and reaction of chemical components in porous media is presented. More specifically there is emphasis on the variation of the overall diffusion resulting from the changing shape of a single pore due to reaction process. These models are derived by averaging, with the use of the multiple scales method. Aspects such as the volume expansion of the material, clogging, etc, due to the material transformation are investigated. The derived macroscopic models are solved numerically and a series of simulations are presented.

Wave propagation through a time-varying heterogeneous interface

Schedule: July 7 15:00-15:30 Room 812

Vishnu Raveendran

University of Bonn, Germany

Co-Author(s): B. Verfürth

Abstract:

We discuss the homogenization and dimension reduction of a wave-type equation with multiple scales in space and time. To perform the homogenization together with dimension reduction, we use the method of multi-scale convergence for thin layer, which is the generalization of the two-scale convergence for a thin heterogeneous layer [M. Neuss-Radu, W. Jäger (2007)]. Special attention is given to deriving the transmission condition along the interface. The study should be seen as the preliminary work to design a time-varying metasurface to control wave propagation

Global existence of weak solutions to an N -dimensional moisture transport model for porous materials

Schedule: July 6 18:00-18:30 Room 812

Yutaka Tsuzuki

Department of Economic Informatics, Hiroshima Shudo University, Japan

Co-Author(s): Tomomi Yokota, Yutaro Chiyo

Abstract:

This talk deals with the moisture transport model for porous materials,

$$\frac{\partial}{\partial t}\psi(u) = \nabla \cdot (\lambda(u)\nabla(u+g)), \quad t \in (0, T), \quad x \in \Omega$$

under the Neumann boundary condition $\frac{\partial}{\partial n}(u+g) = 0$ for $t \in (0, T)$ and $x \in \partial\Omega$ and the initial condition, where $T > 0$, $\Omega \subset \mathbb{R}^N$ ($N \in \mathbb{N}$) is a bounded domain with smooth boundary, ψ, λ, g are given functions satisfying some conditions. In the previous work, global weak solvability and uniqueness were shown under the restriction that $\frac{\lambda}{\psi}$ is constant in the one-dimensional setting. The purpose of this talk is to relax these restrictions and to give an elementary proof of global weak solvability of the above N -dimensional initial-boundary value problem by using the theory for linear operators.

Parabolic gradient flows of energy functionals with state dependent coefficients

Schedule: July 7 17:00-17:30 Room 812

Naotaka Ukai

Department of Mathematics and Informatics, Graduate School of Science and Engineering, Chiba University, Japan

Co-Author(s): Harbir Antil, Daiki Mizuno, Ken Shirakawa

Abstract:

In this talk, we study a parabolic gradient system that integrates two models: the free-energy functional for anisotropic-orientation-adaptive image processing; and the phase-field model of grain-boundary motion. Through the analysis of this gradient system, we aim to construct a unified mathematical framework bridging the two research areas of image processing and materials science. Recently, several attempts have been made to construct a unified framework for the pseudo-parabolic gradient system obtained by incorporating the energy-dissipation operator $-\Delta\partial_t$ into our system. However, the mathematical models for image processing and grain boundary motion are originally formulated as parabolic gradient flows. Therefore, establishing a unified analytical framework for these parabolic models still remains an open problem. In this talk, we address this open problem. Our main objective is to further advance the unification of this mathematical framework through the analysis of our system. Building on the time-discretization method for the pseudo-parabolic system, we carry out the mathematical analysis of the corresponding parabolic system. As a main result, we clarify conditions that ensure the well-posedness of the parabolic system with energy-dissipation. Additionally, in the proof of the main result, we construct an energy-dissipating time-discrete scheme that reduces the cost associated with higher-order derivatives.

On the modelling of the dissolution of a solid particle

Schedule: July 6 13:30-14:00 Room 812

Michael Vynnycky

University of Limerick, Ireland

Abstract:

The dissolution of a solid spherical particle in a surrounding quiescent solvent is a canonical problem that is found in many industrial and consumer applications, ranging from pharmaceutical and food products, to chemicals, detergents, and paints. Mathematically, this constitutes a moving-boundary problem, akin to a classical Stefan problem. However, analysis of a time-dependent, spherically symmetric diffusion-dominated problem indicates a variety of possible pitfalls with the modelling of this problem, even when adopting the seemingly uncontroversial common assumption that the dissolution (reaction) kinetics at the interface are fast compared to mass transfer from the interface, i.e. the limit of infinite Damkohler number. Much of the discussion centres on the appropriate boundary condition that should be used at the dissolution surface in the situation when the density of the solvent is different to that of the particle, as is almost always the case in practice. In particular, we find that the radial solvent flow which dissolution sets into motion results in velocity and pressure singularities when dissolution begins, although the first of these is removed if the Damkohler number is finite.

Qualitative properties of entropy solutions to one-dimensional scalar parabolic-hyperbolic conservation laws

Schedule: July 7 15:30-16:00 Room 812

Hiroshi Watanabe

Oita University, Japan

Co-Author(s): Hiroshi Watanabe

Abstract:

We consider one-dimensional problems (P) for scalar parabolic-hyperbolic conservation laws. These equations may be regarded as a combination of scalar hyperbolic conservation laws and porous medium type equations. Hence, they have both properties of hyperbolic equations and those of parabolic equations. In this talk, we study qualitative properties of entropy solutions to (P). In particular, we focus on the free boundary separating the parabolic and hyperbolic regions. We first review our previous results on the construction of traveling waves, one-sided Lipschitz estimates and decay estimates for entropy solutions. We then investigate the behavior of the free boundary, drawing on propagation estimates for the support of solutions to the porous medium equation and estimates for the interface of the mushy region in the enthalpy formulation of the Stefan problem.

Special Session 84 : Mathematical modeling and analysis in spatial ecology and epidemiology

Organizer(s): Yu Jin , Yijun Lou , Xiaolang Zhao

Introduction: Mathematical modeling and analysis have been powerful in discovering novel dynamics and understanding driving mechanisms for observed phenomena in ecology and epidemiology. Recently, emerging ecological or epidemiological challenges such as those in the context of climate changes or disease outbreaks need urgent attention and lead to new demanding and tough mathematical problems. In this special session, we propose to invite researchers to present recent advances on mathematical modeling and analysis in spatial ecology and epidemiology. The proposed session mainly focuses on mathematical investigation of long-term dynamics and spatial spread of populations or diseases using reaction-diffusion equations (local dispersal) and integrodifferential equations (nonlocal dispersal). This session will serve as a platform for researchers to exchange new ideas and initiate potential collaborations.

Modeling and Data Analysis of Emerging Infectious Disease Transmission Using Stochastic Difference Equations

Schedule: July 9 8:30-9:00 Room 430

Sha He

Shaanxi Normal University, Peoples Rep of China

Abstract:

This study develops stochastic difference equation models to characterize COVID-19 transmission dynamics under random effects. First, we establish a discrete-time stochastic epidemic model using binomial distributions, with parameters estimated from reported data. Next, we construct an improved model that incorporates asymptomatic transmission and imported cases to quantify resurgence risk and evaluate containment measures. An analysis of over 100 Chinese outbreaks reveals small-scale clustered transmission patterns under non-pharmaceutical interventions (NPIs). To investigate how stochastic factors influence the containment process, we derive a stochastic difference equation for newly reported cases based on the stochastic SIR framework and introduce the Stochastic Control Reproduction Number (SCRN). We further estimate the SCRN through Bayesian change-point analysis, and demonstrate via first-passage time theory that controlled randomness can accelerate epidemic containment.

Propagation dynamics for a stage-structured population model in a shifting environment

Schedule: July 9 15:30-16:00 Room 430

Leyi Jiang

School of Mathematics, Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Leyi Jiang, Yu Jin, Xiao-Qiang Zhao

Abstract:

In this talk, we consider an integro-difference system in an unbounded domain for a population with a stage structure consisting of juveniles and adults. The environment shifts between a favorable habitat and an unfavorable habitat at two ends of the domain, which makes the growth and propagation dynamics of the population depend on the changing habitat conditions. Under appropriate assumptions, we establish the existence of spreading speeds and forced traveling waves for such a model. Our analysis of the propagation dynamics is based on the corresponding limiting systems at the far ends of the domain and their relation to the model. It turns out that the habitat shifting speed greatly influences the spreading speeds of the population and may even cause the extinction of the population.

Global dynamics of a predator-prey model with prey-dependent search rate

Schedule: July 8 17:00-17:30 Room 430

Weihua Jiang

School of Mathematics, Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Qiguo Qian

Abstract:

In this talk, we consider a predator-prey model with prey-dependent search rate in advective environments. We investigate the effect of prey-dependent search rate on model dynamics and provide a complete and explicit classification of global dynamics. Moreover, we show that when the limit cycle is stable, the predator can adjust its search rate to stabilize the positive equilibrium, thereby preventing the paradox of enrichment. Specifically, we employ a new planar analysis method to prove that local stability of the positive equilibrium implies global stability.

How Should Species Move? Ideal Free Dispersal in Changing Environments

Schedule: July 9 13:30-14:00 Room 430

King Yeung Lam

The Ohio State University, USA

Co-Author(s): R.S. Cantrell (Miami), C. Cosner (Miami) and H. Zhang (Shanghai Jiaotong).

Abstract:

Understanding how organisms distribute themselves in heterogeneous environments is a central question in ecology. The classical principle of ideal free distribution (IFD) predicts that individuals move so as to equalize fitness across space, and such strategies are known to be evolutionarily stable in static environments. However, real habitats are often time-periodic, and the notion of optimal dispersal in such settings is far less understood. In this talk, we study dispersal strategies in a time-periodic, patchy environment through a system of reaction-diffusion (or patch) models with multiple competing species. We introduce a natural definition of ideal free distribution based on pathwise fitness, and characterize when such distributions can exist. We then show that dispersal strategies leading to IFD are evolutionarily stable: populations converge to an IFD determined by the environment, and species that realize a (joint) IFD can outcompete all others. Our results extend classical theory to systems with multiple competitors or multiple prey and predator species in time-periodic environments. Our main tool is the construction of Lyapunov functions inspired by generalized relative entropy inequality. This is joint work with R.S. Cantrell (Miami), C. Cosner (Miami) and H. Zhang (Shanghai Jiaotong).

Bifurcation of rotating wave solutions in reaction-diffusion systems on a circle

Schedule: July 8 16:30-17:00 Room 430

Junping Shi

College of William & Mary, USA

Co-Author(s): Qingying Cai, Junping Shi, Ying Su

Abstract:

The existence of rotating wave solutions of a general reaction-diffusion system with nonlocal interaction on a circle are proved using a new bifurcation approach with two parameters, and a normal form for the rotating wave bifurcations is also developed to compute the direction of the bifurcation diagram. Theoretical results are applied to two model systems for the existence of rotating waves which are further verified by numerical simulations.

Equivariant Turing-Turing Bifurcations and Pattern Formation on a Square Domain

Schedule: July 8 17:30-18:00 Room 430

Hongbin Wang

School of Mathematics, Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Chen Chen

Abstract:

In this talk, I would like to report one of our recent works on equivariant Turing-Turing bifurcations and pattern formation in square spatial domains. For a relatively general reaction-diffusion systems with self-diffusion and cross-diffusion terms, we derive the local center manifolds near equivariant Turing-Turing singularities. We give approximate expressions for superposition-type steady states and their stability conditions. As an application, we analyze a plant-water interaction model to explore the formation of self-organized vegetation patterns in semi-arid regions.

A nonlocal reaction-diffusion pest model with impulsive larvicidal treatments

Schedule: July 9 9:00-9:30 Room 430

Ruiwen Wu

Jinan University, Peoples Rep of China

Abstract:

Larvicides are pesticides that target immature stages of pests by disrupting their development, thereby reducing survival, causing mortality, and potentially leading to population suppression or extinction. This study constructs a nonlocal periodic delayed reaction-diffusion model to describe the effects of impulsive larvicide applications on pest populations in a spatially and temporally heterogeneous environment. Furthermore, the threshold dynamics of the model are established through dynamical systems analysis. The numerical results indicate that larvicides can play a significant role in pest management; however, their application strategies need to be carefully designed. In addition, ignoring spatial heterogeneity in model formulation may lead to a misestimation of the risk of pest outbreaks.

Modelling heterogeneity and its impact on disease transmission dynamics

Schedule: July 9 8:00-8:30 Room 430

Yanni Xiao

Xi'an Jiaotong University, Peoples Rep of China

Co-Author(s): Yanni Xiao, Biao Tang, Pengfei Song

Abstract:

Human heterogeneity is a critical issue in infectious disease transmission dynamics modelling, and it has recently received much attention in COVID-19 studies. In this talk, a novel model with heterogeneity in susceptible individuals is proposed to accurately estimate the final size. Then, a general human heterogeneous disease model with mutation is proposed to comprehensively study the effects of human heterogeneity on basic reproduction number, final epidemic size and herd immunity. We show that human heterogeneity may increase or decrease herd immunity level, strongly depending on some convexity of the heterogeneity function.

Global Dynamics of Nonlocal Dispersal Systems with Time-Varying Domains

Schedule: July 9 14:30-15:00 Room 430

Hailong Ye

Shenzhen University, Peoples Rep of China

Abstract:

In this talk, I will report our recent research on the asymptotic behaviour of a class of nonlocal dispersal systems with time-varying domains. We first establish the comparison principle for generalized sub- and supersolutions of nonautonomous nonlocal dispersal systems. Based on the spectral bound, we rigorously characterize the threshold dynamics of nonautonomous nonlocal dispersal systems in the time-periodic case, which provide a comprehensive framework to examine the threshold dynamics of the original system on asymptotically fixed and time-periodic domains. In the asymptotically unbounded case, we introduce an auxiliary function to overcome the challenges arising from the asymptotically vanishing viscosity in the system and the time-dependent coupling structure in kernel. This talk is based on joint work with Prof. Xiao-Qiang Zhao and Dr. Xiandong Lin, which has been published by JDE (2026).

Convergence to forced waves of integro-difference equations in a shifting environment

Schedule: July 9 14:00-14:30 Room 430

Xiao Yu

South China Normal University, Peoples Rep of China

Abstract:

We study integro-difference equations in shifting habitats. We establish the existence of forced waves and prove convergence to these waves in a moving coordinate system, provided that both limiting environments admit KPP-type structures and the rightward spreading speed coincides with the habitat speed.

Well-posedness and propagation dynamics of reaction-diffusion equations with Borel-measure coefficients

Schedule: July 9 15:00-15:30 Room 430

Ziqi Zhen

School of Mathematical Sciences, University of Science and Technology of China, Hefei, Anhui 230026, People's Republic of China, Peoples Rep of China

Co-Author(s): Xing Liang

Abstract:

We study the equation $u_t = u_{xx} + \beta(x; L)g(u) - au$, $x \in \mathbb{R}$, where the Borel-measure coefficient $\beta(x; L)$ represents the local density of calcium release sites with L being the separation between release sites and $g(u)$ satisfies a weak Allee effect condition. The model describes intracellular waves in a continuum excitable media with discrete release sites. In this paper, we first establish the well-posedness of the Cauchy problem for general Borel-measure $\beta(x; L)$ within a rigorous mathematical framework, using an approximation procedure. Next, we investigate the propagation dynamics of the model where $\beta(x; L)$ is an L^1 perturbation of the periodic Dirac sources $\sum_{n=-\infty}^{+\infty} \delta(x - nL)$ and $g(u) = u^p(1 - u)$ with the integer $p \geq 2$. We focus on the bistable regime of the model, which is determined by the decay strength parameter a and the separation distance L between release sites, in which the model admits exactly three L -periodic steady states. We establish the existence of pulsating waves that spatially connect stable steady states by a dynamical systems approach. Furthermore, we prove that any such traveling wave with nonzero speed is both unique and globally exponentially stable via the squeezing method.

Special Session 85 : Phase-field models and their singular limits

Organizer(s): Andrea Poiatti , Helmut Abels , Harald Garcke

Introduction: Phase-field models are a powerful approach to describe a variety of phenomena, from phase separation to multi-phase flows, from cell membranes evolution to tumor growth. These models allow to capture the phase evolution by means of a diffuse interface approximation, leading to highly nonlinear partial differential equations. On the other hand, free boundary problems are also well established to describe the same phenomena, and the phase-field models can be seen as their diffuse interface approximations. These connections through sharp interface limits have been attracting more and more researchers, and an impressive amount of new results has recently been obtained. Also, many other singular limits connected to phase field modeling have been studied in the last years, ranging from incompressible limits (like in tumor growth dynamics) to nonlocal-to-local limits, connecting nonlocal models (accounting for long-range interaction effects) with their corresponding local counterparts. In this session, we aim at bringing together researchers active in the study of phase-field models and their singular limits, in order to tackle the most challenging and updated advances of the theory, and possibly propose new directions for further investigation.

Deterministic particle approximation of a fourth-order PDE

Schedule: July 9 9:00-9:30 Room 437

Charles Elbar

Universite Claude Bernard Lyon 1, France

Co-Author(s): Alejandro Fernandez-Jimenez

Abstract:

Many partial differential equations describe how a macroscopic density of particles/cells evolves in time. So, it is a natural question to ask whether there is a microscopic (deterministic) model that leads to a given macroscopic PDE. For second-order aggregation-diffusion equations, this connection has been proved, starting with the porous medium equation in 2001. In this work, we extend that framework to a fourth-order equation, inspired by applications in cell-cell adhesion in biological systems. This is a joint work with Alejandro Fernandez-Jimenez.

A Cahn-Hilliard-Darcy-Forchheimer surfactant model

Schedule: July 8 13:30-14:00 Room 437

Maurizio Grasselli

Politecnico di Milano, Italy

Co-Author(s): B. Ouyang, A. Poiatti, H. Wu

Abstract:

We present a mathematical model for two-phase flows with surfactants in porous media, combining a Darcy--Forchheimer equation with two Cahn--Hilliard equations involving singular potentials. We show the existence of global weak solutions and that, over time, every solution converges to a single equilibrium. A key point is that this convergence holds at the level of weak solutions, without requiring extra regularity, which distinguishes this result from much of the existing literature. Further related results will also be discussed if time permits.

A weak-strong uniqueness principle for Mullins-Sekerka flow

Schedule: July 8 9:30-10:00 Room 437

Sebastian Hensel

University of Leipzig, Germany

Co-Author(s): Julian Fischer, Tim Laux, Theresa M. Simon

Abstract:

We establish a weak-strong uniqueness principle for the two-phase Mullins-Sekerka equation in ambient dimension $d = 2$ and 3 : As long as a classical solution to the evolution problem exists, any weak De Giorgi type varifold solution (see for this notion the recent work with Stinson, Arch. Ration. Mech. Anal. 248, 8, 2024) must coincide with it. In particular, in the absence of topology changes such weak solutions do not introduce a mechanism for (unphysical) non-uniqueness. We also derive a stability estimate with respect to changes in the data. I will explain our method which is based on the notion of relative entropies for interface evolution problems, a reduction argument to a perturbative setting, and a stability analysis in this perturbative regime relying crucially on the gradient flow structure of the Mullins-Sekerka equation.

Two-phase flow with micropolar effects: Modelling, analysis and asymptotic limits

Schedule: July 8 14:30-15:00 Room 437

Kei Fong Lam

Hong Kong Baptist University, Hong Kong

Co-Author(s): Kin Shing Chan, Michael Eden, Baoli Hao, Bjorn Stinner

Abstract:

Micropolar fluids are among the simplest cases of fluids with microstructures, where each fluid particle has its own internal rotations. Examples include ferrofluids, blood flows, bubbly liquids and liquid crystals. By combining the seminal work of A. Cemal Eringen and coworkers, with the diffuse interface approach for multiphase fluid flow, we develop new diffuse interface models for binary mixtures of micropolar fluids. Using recent advances in the mathematical analysis of such types of models, we establish existence of weak solutions and discuss several asymptotic limits, such as micropolar-to-nonpolar, nonlocal-to-local convergence, as well as flow within Hele-Shaw type thin domains.

Sharp Interface Limit for 3D Navier-Stokes/Allen Cahn Systems

Schedule: July 8 17:30-18:00 Room 437

Yadong Liu

Nanjing Normal University, Peoples Rep of China

Co-Author(s): Helmut Abels, Mingwen Fei, Yadong Liu, and Maximillian Moser

Abstract:

In this talk, I will report a recent work on the sharp interface limit of a coupled Navier--Stokes/Allen--Cahn system in a three dimensional, bounded and smooth domain, when a parameter $\varepsilon > 0$ that is proportional to the thickness of the diffuse interface tends to zero, rigorously. The argument is based on the method of rigorous matched asymptotic expansions. In particular, we obtain optimal estimates for the linearized error system in L^2 -Sobolev type spaces, which are second order in space of $\mathbf{w}$ and third order in space for u , with suitable weights. This provides better description of the system close to the interface, which leads us to extend previous results from two dimensions to three dimensional case.

The Verigin problem with phase transition as Wasserstein flow

Schedule: July 9 9:30-10:00 Room 437

Alice Marvaggio

University of Bonn, Germany

Co-Author(s): Anna Kubin and Tim Laux

Abstract:

We study the modeling of a compressible two-phase flow in a porous medium. The governing PDE system is known as the Verigin problem with phase transition, which is the compressible analog to the Muskat problem. We prove the convergence of an implicit time discretization scheme using the Wasserstein distance, obtaining distributional solutions in the limit that satisfy an optimal energy-dissipation rate. Finally, we propose a phase-field model for the Verigin problem with phase transition and study its sharp-interface limit.

Singular limit of phase field models on varying surfaces

Schedule: July 8 9:00-9:30 Room 437

Matthias R\"oger

Department of Mathematics, TU Dortmund University, Germany

Co-Author(s): Heiner Olbermann, UC Louvain and Benjamin Lledos

Abstract:

We consider the sharp interface limit of phase field models on varying surfaces. Our approach uses the concept of BV functions over rectifiable currents introduced by Anzellotti, Delladio and Scianna [Annali di Matematica Pura ed Applicata, 1996]. In particular we will address Cahn-Hilliard type energies and a diffuse approximation of a $\mathcal{J}_u$ -Lipowsky type variational model for phase separated biomembranes. (This is joint work with Heiner Olbermann, UC Louvain and Benjamin Lledos, Universit  de N mes)

Active Phase Separation and Self-Organizing Droplets

Schedule: July 8 15:00-15:30 Room 437

Andrea Signori

Politecnico di Milano, Italy

Co-Author(s): Harald Garcke, Kei Fong Lam, Robert N rnberg

Abstract:

Active phase separation leads to behaviors that significantly differ from those of classical systems. Instead of the usual coarsening, where larger droplets grow at the expense of smaller ones, chemically active mixtures can maintain stable populations of finite-sized droplets, which may even grow, divide, or form more complex structures. These dynamics have been proposed as simple models for protocells and early self-organizing biological structures. In this talk, I present a mathematical framework for active droplet dynamics based on two complementary descriptions: the phase-field Cahn-Hilliard equation and its sharp-interface limit given by the Mullins-Sekerka free-boundary problem. I discuss the relation between these models, address questions of well-posedness and stability in symmetric settings, and conclude with numerical simulations illustrating phenomena such as droplet division and shell formation.

Convergence Rates for Adversarial Training

Schedule: July 9 8:30-9:00 Room 437

Kerrek Stinson

University of Utah, USA

Co-Author(s): L. Bungert, R. Morris, R. Murray

Abstract:

We discuss some qualitative and quantitative results analyzing adversarial training as the adversarial budget vanishes. First, with Bungert, we find that minimizers of the adversarial training problem converge in L^1 to a Bayes classifier that has minimal weighted perimeter, showing that adversarial training acts as a selection mechanism for the standard classification problem. Subsequent work by Morris and Murray showed that adversarial minimizers converge to Bayes classifiers in the (much stronger) Hausdorff metric at a rate that degrades with the dimension. Joining forces, we recover the generically optimal rate of convergence and prove that the Hausdorff distance between the adversarial minimizer and the Bayes classifier is $O(\epsilon)$ regardless of the ambient dimension.

Brakke's inequality and the existence of Brakke flow for volume preserving mean curvature flow

Schedule: July 8 17:00-17:30 Room 437

Keisuke Takasao

Kyoto University, Japan

Co-Author(s): Andrea Chiesa

Abstract:

We consider the existence of the weak solutions to the volume preserving mean curvature flow. The Brakke flow defined using Brakke's inequality is well known as one of the weak solutions to the mean curvature flow. On the other hand, the volume preserving mean curvature flow has been studied via L^2 -flow solution, BV solution, and flat flow, but the corresponding Brakke flow had not been considered so far. In this talk, we define the suitable Brakke flow for the volume preserving flow and show its global existence. This talk is based on joint works with Andrea Chiesa.

Existence and Nonlocal-to-Local Convergence for Singular, Anisotropic Nonlocal Cahn-Hilliard Equations

Schedule: July 9 8:30-9:00 Room 437

Yutaka Terasawa

Nagoya University, Japan

Abstract:

We study the nonlocal-to-local convergence for a nonlocal Cahn-Hilliard equation with anisotropic and singular kernels. In particular, we show convergence of weak solutions of the nonlocal Cahn-Hilliard equation to weak solutions of a corresponding anisotropic Cahn-Hilliard equation for suitable subsequences. Moreover, we show existence of weak solutions for the nonlocal equation under a condition, which guarantees existence of weak solutions for suitably localized or singular kernels. We put a focus on the existence part in the talk. This is based on a joint work with Helmut Abels (Regensburg Univ.)

Some problems for two-phase flow coupled with the Allen-Cahn equation

Schedule: July 8 16:30-17:00 Room 437

Yoshihiro Tonegawa

Institute of Science Tokyo, Japan

Abstract:

I consider a simple two-phase fluid model where the flow field satisfies a non-Newtonian equation in the bulk and the interface moves by the normal velocity given by the normal component of the flow field plus κ times the mean curvature of the interface itself. The model can be formally obtained as the singular perturbation limit of a coupled system involving the Allen-Cahn equation and we are particularly interested in the existence and regularity issues of the weak solution in the setting of geometric measure theory. I describe what has been attempted in this direction with some recent advances, as well as the related problems.

Rayleigh-Taylor problem for incompressible two-phase flows with unmatched densities

Schedule: July 8 14:00-14:30 Room 437

HAO WU

Fudan University, Peoples Rep of China

Co-Author(s): Fei Jiang, Maoyin Lv, Hao Wu

Abstract:

We investigate the Rayleigh-Taylor (RT) problem within the framework of diffuse-interface models for incompressible two-phase flows with unmatched densities under a uniform gravitational field. For the three-dimensional Abels-Garcke-Gr $\{u\}$ n system, we demonstrate that sufficiently large viscosity or mobility can inhibit the RT instability under appropriate stability conditions. Moreover, we establish a stability criterion that involves the system's coefficients.

Special Session 86 : Advances in Differential, Difference and Dynamic Equations with Applications in Science and Engineering

Organizer(s): Elvan Akin , Billur Kaymakcalan , Ozkan Ozturk

Introduction: Differential equations and difference equations are essential tools in modeling real-world problems such as physics, statistics, economics, biology, and engineering. In 1988, Stefan Hilger introduced a powerful tool that unifies these two distinct areas and extends these theories to a general theory, so called the theory of time scales. The main purpose of the special session is to bring together researchers working in the areas of differential equations, difference equations, and dynamic equations on time scales. The session will focus on the latest advancements in various related topics, such as the modeling of real-world phenomena, the asymptotic behavior of solutions, boundedness and periodicity of solutions, non-oscillation and oscillation of solutions, stability, numerical algorithms, computational aspects, and their applications across different scientific and engineering disciplines.

Analysis of Initial Conditions of Various Discrete Dynamic Equations and Iterated Function Systems using Visual Heuristics

Schedule: July 10 8:30-9:00 Room 428

Chris Ahrendt

University of Wisconsin-Eau Claire, USA

Abstract:

Inspired by the fractal images produced by the Electric Sheep project started in 1999 by Scott Draves, we seek to analyze the underlying iterated function systems (IFSs) that are used to produce these fractal images. Since the IFSs involve multiple nonlinear functions selected using a random process, some of the traditional analytic techniques from difference equations run into difficulties. In this work stemming from a recent undergraduate student research collaboration, we will give some background on the Electric Sheep project and how the underlying IFSs are utilized to produce images. The Electric Sheep project focuses on the aesthetics of the resulting images. Here, we seek to develop several visual heuristics (some that are interactive) in order to analyze the mathematical behavior of orbits with various initial conditions for the IFSs that produce these images. We visualize the nullclines using approximations to account for the nonlinear and random aspects of the IFSs. We will develop several heuristics that incorporate ideas involving domain coloring from complex variables in order to construct the visualization for the heuristics. Finally, we apply these techniques to discrete analogs of certain DEs such as the Clairaut equation, the Bernoulli equation, and the Lotka-Volterra system of equations.

Modeling HIV-1 Infection Dynamics Using Mathematical and Statistical Approaches

Schedule: July 10 13:30-14:00 Room 428

Elvan Akin

Missouri University of Science and Technology, USA

Co-Author(s): N.N.Pelen, O. Ozturk, G.R. Olbricht, A.S. Perelson

Abstract:

In this study, we examine the dynamics of HIV-1 infection using mathematical models that capture both patient-specific behavior and population-level patterns. The model is formulated as a three-dimensional system describing the interactions between uninfected target cells, infected target cells, and viral load. We first perform mathematical model fits using longitudinal RNA measurements from individual patients, allowing parameters to be estimated directly from clinically observed data. In addition to this mathematical modeling approach, we conduct a statistical analysis across the patient cohort to investigate population-level patterns. Interestingly, the same patients emerge as the best-fitting cases under both approaches, indicating strong agreement between the mathematical modeling results and the statistical population analysis.

Chebyshev Collocation Method for a Three-Dimensional HIV Infection Model

Schedule: July 10 14:00-14:30 Room 428

Beyza Cetin

Missouri University Science and Technology, USA

Co-Author(s): Beyza Cetin, Elvan Akin, Alan Perelson

Abstract:

Nonlinear differential equations frequently arise in mathematical models describing viral infection dynamics, where analytical solutions are rarely available. Therefore, reliable numerical methods are required to approximate the behavior of such systems. In this study, we propose a numerical approach based on the Chebyshev collocation method for solving nonlinear systems appearing in HIV infection models. The method approximates the solution components using Chebyshev polynomial expansions and enforces the governing equations at selected collocation points. This formulation transforms the original nonlinear differential system into a system of algebraic equations that can be solved efficiently using standard numerical techniques. Due to the spectral accuracy of Chebyshev polynomials, the proposed approach provides highly accurate approximations with relatively low computational cost. To demonstrate the applicability of the method, we apply the proposed scheme to a three-dimensional HIV infection model describing the interaction between healthy cells, infected cells, and virus particles. Numerical simulations show that the method accurately captures the qualitative behavior of the system dynamics. In addition, the formulation suggests that the proposed collocation framework can be extended to models defined on time scales, providing a potential tool for studying systems involving both continuous and discrete temporal structures.

Inverse Forms of Pachpatte-Type Dynamic Inequalities within Diamond-Alpha Calculus

Schedule: July 10 11:00-11:30 Room 428

Billur Kaymakçalan

University of Turkish Aeronautical Association, Turkey

Co-Author(s): Zeynep Kayar

Abstract:

Through the application of concavity, we derive novel reversed diamond alpha Pachpatte type dynamic inequalities. These formulations not only encompass the nabla and delta analogues but also merge both the discrete and continuous frameworks as particular instances. Moreover, in the absence of concavity, they naturally give rise to generalized versions of the diamond alpha Bennett Leindler type dynamic inequalities.

\title{Bifurcation Analysis of a Smith-Type Growth Predator--Prey Model and Its Application}

Schedule: July 10 9:30-10:00 Room 428

Md Mutakabbir Khan

Missouri University of Science and Technology, USA

Co-Author(s): Elvan Akin, Md Jasim Uddin

Abstract:

This work develops and analyzes a prey--predator model in which the prey population exhibits Smith-type growth, group-defense behavior, and continuous external replenishment. A forward--Euler discretization produces a two-dimensional map whose positivity, boundedness, and equilibrium stability are established. Bifurcation analysis shows that the coexistence equilibrium may lose stability through Neimark--Sacker or period-doubling bifurcations, leading to quasiperiodic or chaotic dynamics. Numerical simulations, including bifurcation diagrams, phase portraits, and Lyapunov exponents, reveal rich dynamical behaviors. A global sensitivity analysis using partial rank correlation coefficients identifies parameters that most strongly influence long-term species densities. Finally, calibration with COVID-19 and tuberculosis surveillance data demonstrates the potential applicability of the framework under a phenomenological interpretation.

New Theorems for Determining the Global Dynamics of Anti-Competitive Systems

Schedule: July 10 9:00-9:30 Room 428

Chris D Lynd

Commonwealth University of Pennsylvania, USA

Abstract:

We will present new theorems that can be used to determine the global dynamics of the solutions of anti-competitive systems of difference equations. We will give a brief background on anti-competitive maps and some insights into how to apply the theorems. We will also present some applications of anti-competitive systems of difference equations.

\title{Bifurcation and Chaos Control in a Discrete Predator-Prey Model with Fear Effect and Immigration}

Schedule: July 10 14:30-15:00 Room 428

Esrat Nur

Louisiana State University, USA

Abstract:

This work investigates the discrete-time dynamics of a predator-prey model incorporating a square root functional response, fear effect, and immigration. Using bifurcation theory and center manifold analysis, the study establishes the occurrence of period-doubling and Neimark-Sacker bifurcations in the positive quadrant. Numerical simulations support the analytical results and illustrate complex behaviors such as high-period orbits, quasi-periodic invariant curves, and chaotic attractors. To control chaotic dynamics, both the Ott-Grebogi-Yorke technique and a state-feedback control method are applied, showing that the system can be guided toward a stable equilibrium. The results provide useful insight into the dynamics and control of nonlinear ecological systems.

Existence Results for Third-Order Nonlinear Dynamic Equations

Schedule: July 10 10:30-11:00 Room 428

Ozkan Ozturk

Giresun University, Turkey

Co-Author(s): Elvan Akin, Neslihan Nesliye Pelen

Abstract:

We study a third-order nonlinear dynamic equation on arbitrary time scales, namely, nonempty closed subsets of the real numbers, which unify continuous and discrete analysis within a single framework. Our main focus is on the qualitative properties of nonoscillatory solutions and their quasi-derivatives, especially their asymptotic behavior. By employing improper integral criteria and applying fixed point theorems, we establish the existence of such solutions.

The effect of very fast dispersal on two species competition with drift

Schedule: July 10 11:30-12:00 Room 428

Rana Parshad

Iowa State University, USA

Abstract:

Classical theory predicts that for two competing populations subject to a constant downstream drift, the faster disperser will competitively exclude the slower disperser. In the current work, we consider a novel model of a much faster dispersing species, modeled via a p -Laplacian operator, competing with a slower disperser. We prove global existence of weak solutions to this model for any positive initial condition, in certain parametric regime. Counterintuitively, we show that while the faster disperser always wins - the much faster disperser could actually lose, for certain initial data. Our results have implications for biodiversity, refuge design, and improved biological control, driven by habitat fragmentation and climate change

Modeling Influenza Transmission Across Ecological Scales: Aquatic Birds, Domestic Poultry, and Humans

Schedule: July 10 12:00-12:30 Room 428

Naveen K. Vaidya

San Diego State University, USA

Co-Author(s): Naveen K. Vaidya

Abstract:

Climate, especially environmental temperature, plays a critical role in shaping the transmission, evolution, and persistence of highly pathogenic influenza viruses in aquatic birds, thereby driving epidemics in domestic poultry and, eventually, in humans. In this talk, I will present transmission dynamics models of influenza across different scales: aquatic birds, domestic poultry, and humans. Analysis of our data-validated models allows us to identify climate conditions that favor the persistence of highly pathogenic influenza strains among aquatic birds. The models also provide the risk of cross-species transmission and epidemic spread in domestic poultry and humans. Our results indicate that climate functions as a selective filter shaping both the transmission, evolution, and invasion potential of influenza across species.

Special Session 87 : Mathematical Insights into Phase-Field Models

Organizer(s): Andrea Signori , Pierluigi Colli , Takeshi Fukao

Introduction: Interface evolution is central to many physical, biological, and technological processes. Phase-field methods provide a powerful framework for modeling such dynamics, offering a diffuse-interface alternative to classical sharp-interface approaches. These models handle complex topological changes and multi-scale phenomena while maintaining strong links to geometric and variational structures. This session focuses on the mathematical theory, modeling, and simulation of evolving interfaces, with an emphasis on phase-field and related methods. Topics include Cahn–Hilliard and Allen–Cahn systems, sharp-interface limits, dynamic boundary conditions, control problems, well-posedness, and asymptotic behavior. Applications span materials science, fluid dynamics, biology, biomedicine, and image processing. We welcome analytical, numerical, and interdisciplinary contributions that advance our understanding of interface-driven phenomena.

Uniform higher order estimates for the sharp interface limit of a Navier-Stokes/Allen-Cahn system

Schedule: July 6 15:00-15:30 Room 740

Helmut Abels

University of Regensburg, Germany

Co-Author(s): Mingwen Fei, Yadong Liu, Maximilain Moser

Abstract:

We consider the linearized system for the sharp interface limit of a Navier-Stokes/Allen-Cahn system around a suitable approximate solution. With the aid of a suitable weight taking the distance to the interface and the interfacial thickness into account we obtain optimal regularity estimates, which are uniform in the interfacial thickness. This enables to improve previous convergence results in two space dimensions significantly and extend results to three space dimensions.

New results on a variant of the Cahn-Hilliard equation with non-variational structure

Schedule: July 6 14:00-14:30 Room 740

Abramo Agosti

University of Pavia, Italy

Co-Author(s): Andrea Giorgini

Abstract:

In this talk I will present a variant of the Cahn-Hilliard equation well-known in the Statistical Physics community, which is not derivable from variational principles and which may describe continuum materials constituted by particles that can convert energy into directed motion. This model has multiple applications in biomedicine and engineering. I will show quantitative results about the phase-separation and coarsening dynamics, and both analytical and numerical results for the model equation.

Optimal Control of the Fidelity Coefficient in Cahn--Hilliard Inpainting Models

Schedule: July 6 17:00-17:30 Room 740

Cecilia Cavaterra

University of Milan, Italy

Co-Author(s): Elena Beretta, Matteo Fornoni, Maurizio Grasselli

Abstract:

We study an optimal control problem for a Cahn--Hilliard-type inpainting model, as originally proposed by Bertozzi et al. The model employs a linear reaction term, weighted by a fidelity coefficient, to restore a damaged image within a fixed subdomain. To ensure that the order parameter remains within the physically relevant range $[0, 1]$, we employ a singular potential. We formulate a cost functional that accounts for the magnitude of the fidelity coefficient and analyze the resulting control-to-state operator. After proving the existence of optimal controls, we derive first-order optimality conditions and, under suitable assumptions, establish second-order optimality conditions.

A perturbation of the Cahn-Hilliard equation with logarithmic nonlinearity

Schedule: July 6 13:30-14:00 Room 740

Monica Conti

Politecnico di Milano, Italy

Co-Author(s): Pietro Galimberti, Stefania Gatti, Andrea Giorgini

Abstract:

We investigate a perturbation of the Cahn-Hilliard equation with non-degenerate mobility and nonlinear terms of logarithmic type. This new model is based on an unconstrained theory recently proposed by F.P. Duda, A.F. Sarmiento and E. Fried. We prove the existence, regularity and uniqueness of weak and strong solutions, as well as separation properties from the pure states, also in three space dimensions. Besides, we prove the convergence to the Cahn-Hilliard equation as the perturbation parameter goes to zero.

On recent analytical results for a thermodynamically consistent diffuse interface model for incompressible two-phase flows with unmatched densities

Schedule: July 7 15:30-16:00 Room 740

Harald Garcke

Department for Mathematics, Germany

Co-Author(s): Helmut Abels, Andrea Giorgini, Maoyin Lv, Hao Wu

Abstract:

In the talk, an initial-boundary value problem for the incompressible Navier-Stokes-Cahn-Hilliard system with non-constant density, proposed by the speaker together with Abels and Grün in 2012, will be analyzed. This model arises in the diffuse interface theory for binary mixtures of viscous incompressible fluids. This system is a generalization of the well-known model H in the case of fluids with unmatched densities. In three dimensions, we prove that any global weak solution (for which uniqueness is not known) exhibits a propagation of regularity in time and stabilizes toward an equilibrium state for large times. The analysis hinges upon the following key points: a global regularity result (with explicit bounds) for the Cahn-Hilliard equation with divergence-free velocity, the energy dissipation of the system, the separation property at large times, a weak-strong uniqueness type result, and the Łojasiewicz-Simon inequality. We then discuss mixed regularity conditions on the velocity field and its gradient, under which the global weak solution conserves its energy for all times. Finally, we show Lyapunov stability for each steady state consisting of a zero velocity together with a local energy minimizer of the Ginzburg-Landau functional.

On the Cahn-Hilliard equation with nonlinear diffusion: the non-convex case

Schedule: July 7 13:30-14:00 Room 740

Andrea Giorgini

Politecnico di Milano, Italy

Co-Author(s): Monica Conti, Stefania Gatti, Giulio Schimperna

Abstract:

We investigate the Cahn-Hilliard equation with nonlinear diffusion and non-degenerate mobility modeling phase separation phenomena in complex systems (e.g., crystals and polymers). Previous results in the literature on this model relied on the strong convexity assumption of the gradient part of the energy, which excludes relevant cases. In this talk, we remove the convexity condition and establish new qualitative properties of solutions under general assumptions on the diffusion and mobility functions. In two spatial dimensions, we prove uniqueness of weak solutions, their smoothing effect for positive times, and convergence to equilibrium as time tends to infinity. In three dimensions, we show local well-posedness of strong solutions for arbitrary initial data and global existence for data close to energy minimizers, yielding a Lyapunov stability principle. A key ingredient of our analysis is a Łojasiewicz-Simon inequality tailored to the nonlinear diffusion case, which enables us to characterize the longtime dynamics.

Fast reaction limit in a stochastic competition-diffusion system

Schedule: July 7 9:00-9:30 Room 740

Danielle Hilhorst

CNRS and Universiy Paris-Saclay, France

Co-Author(s): Perla El Kettani, Kunwoo Kim

Abstract:

We study the fast reaction limit of a stochastic competition-diffusion system and prove that its solution converges to the unique solution of a stochastic Stefan problem with zero latent heat as the reaction term tends to infinity.

Strong nonlocal-to-local convergence of convolution operators with singular, possibly anisotropic kernels

Schedule: July 7 14:30-15:00 Room 740

Patrik Knopf

University of Regensburg, Germany

Co-Author(s): Helmut Abels, Christoph Hurm

Abstract:

The goal of nonlocal-to-local convergence is to show that certain singular, nonlocal convolution-type integral operators converge to a local differential operator as the convolution kernel concentrates at zero. This can be a useful tool in the physical justification of mathematical models (e.g., the Cahn--Hilliard equation), especially when a desired local differential operator can not be derived by microscopic laws. The nonlocal-to-local convergence of convolution operators with radially symmetric (i.e., isotropic) kernels having $W^{1,1}$ -regularity is already very well understood. However, the assumption of $W^{1,1}$ -regularity is too strong for many applications. Also, in some situations (e.g., crystallization phenomena), convolution kernels are not radially symmetric but merely even (i.e., anisotropic). In my talk, I will present our recent results on the strong nonlocal-to-local convergence (with rates) for anisotropic kernels with significantly lower regularity assumption compared to previous contributions. These results can, for example, be applied to nonlocal phase-field models such as some anisotropic variants of the Cahn--Hilliard equation.

Complex pattern formation by Ginzburg-Landau and Swift-Hohenberg dynamics: Analysis and Numerical Simulations

Schedule: July 6 14:30-15:00 Room 740

Kei Fong Lam

Hong Kong Baptist University, Hong Kong

Co-Author(s): Harald Garcke, Robert Nurnberg, Andrea Signori and Ho Hei Tam

Abstract:

We discuss pattern formation arising from combinations of Ginzburg-Landau and Swift-Hohenberg dynamics. Individually these are well-studied processes where the former involves separation into phases and the latter involves small scale stripes and dots. Such systems were proposed to generate new patterns by leveraging the competition between Ginzburg-Landau and Swift-Hohenberg dynamics, and were suggested for the development of new porous structures for material sciences. We present a three-species mixture described by a Cahn-Hilliard-Swift-Hohenberg system. Singular potentials are introduced to adhere to essential physical constraints, and well-posedness results will be reported. Numerical simulations demonstrate complex pattern formation as seen in pigment patterns of animals. If time permits, we discuss the numerical analysis of a positive preserving scheme for solving such Cahn-Hilliard-Swift-Hohenberg system with singular potentials.

Global weak solutions to a diffuse interface model for quasi-incompressible two-phase flows with barycentric velocity and singular potential

Schedule: July 7 14:00-14:30 Room 740

Yadong Liu

Nanjing Normal University, Peoples Rep of China

Co-Author(s): Mingwen Fei, Xiang Fei, Yadong Liu and Hao Wu

Abstract:

In this talk, I will discuss a thermodynamically consistent diffuse-interface model that describes the motion of two macroscopically immiscible, incompressible, viscous fluids with unmatched densities. This model adopts a mass-averaged velocity so that the fluid mixture is quasi-incompressible: the velocity is no longer divergence-free, and the pressure enters the equation for the chemical potential. For the initial boundary value problem in $\mathbb{T}^3$ with a class of physically relevant and singular free energy densities, we prove the existence of global-in-time weak solutions. The proof relies on a reduction of the model and a two-layer approximation with delicate estimates for the order parameter and the mass density that are inspired by the celebrated BD-entropy introduced by Bresch and Desjardins [Comm. Math. Phys. 2003, 238(1-2): 211--223]. A key observation is that capillarity at the interface provides a damping effect on the density evolution. Moreover, for the limiting passage, delicate tail estimates are derived to exclude possible concentrations of the singular potential, since no integrability of the pressure is available a priori. This work appears to be the first existence result for the Navier--Stokes/Cahn--Hilliard system with general densities and barycentric velocity without spatial regularization.

A high-order spatially accurate structure-preserving scheme for PDEs with dynamic boundary conditions based on a summation-by-parts operator

Schedule: July 7 9:30-10:00 Room 740

Makoto Okumura

Intelligence and Informatics/Konan University, Japan

Abstract:

The Summation-by-Parts (SBP) method is a spatial discretization technique for partial differential equations (PDEs) that employs the SBP operator to approximate spatial partial derivatives. Moreover, some SBP operators provide highly accurate approximations of spatial partial derivatives, and their use is expected to yield high-precision spatial discretization of PDEs. On the other hand, there is a structure-preserving numerical method called the discrete variational derivative (DVD) method by Furihata and Matsuo (2010). The scheme derived from this method is typically second-order accurate in space. More recently, Umezu et al. (2025) have designed a structure-preserving scheme with high-order spatial accuracy based on the DVD method for the Cahn--Hilliard equation with homogeneous Neumann boundary conditions, using the SBP operator and an appropriate projection matrix. However, constructing such a projection matrix is difficult for complex boundary conditions, such as dynamic ones that involve the time derivative of an unknown function. Thus, in this study, instead of using a projection matrix, we incorporated a correction term, the simultaneous approximation (SA) term, corresponding to the residual of the boundary conditions. This enabled us to design a spatially high-accuracy structure-preserving scheme based on the DVD method for PDEs under dynamic boundary conditions.

A stochastic Allen-Cahn equation with jumps for radiotherapy damage

Schedule: July 7 8:30-9:00 Room 740

Luca Scarpa

Politecnico di Milano, Italy

Co-Author(s): Andrea Di Primio, Marvin Fritz, Margherita Zanella

Abstract:

We present a stochastic Allen-Cahn equation for the dynamics of biomolecular damage and repair. The jump-type noise models the abrupt, localised damage induced by external radiotherapy shocks. We prove well-posedness of the model in a strong probabilistic sense and present some simulations to illustrate how it captures fundamental biological phenomena, such as damage clustering, stress-induced topology perturbations, and damage dynamics. The works presented in the talk are based on joint collaborations with Andrea Di Primio (Scuola Normale Superiore, Pisa, Italy), Marvin Fritz (University of Vienna, Austria), and Margherita Zanella (Politecnico di Milano, Italy).

Optimal Control of 1D Nonlinear Parabolic System Involving Regularized 1-Harmonic Type Flow

Schedule: July 6 17:30-18:00 Room 740

Ken Shirakawa

Faculty of Education, Japan

Co-Author(s): Salvador Moll and Hiroshi Watanabe

Abstract:

This study is based on recent jointwork with S. Moll (University of Valencia, Spain) and H. Watanabe (Oita University, Japan). In this talk, we consider an optimal control problem governed by a one-dimensional nonlinear parabolic system involving a regularized 1-harmonic type flow, which serves as a model of grain boundary motion. The state system is a one-dimensional simplified version of the three-dimensional phase-field model for grain boundary motion studied in [S. Moll et al., J. Nonlinear Sci., 33, 2023]. The optimal control problem is formulated under a state constraint requiring that the range of the state variable is restricted to the unit sphere, together with a control constraint imposed on the domain of the cost functional. In particular, the state constraint introduces essential analytical difficulties in both the mathematical model and the optimal control problem. The aim of this talk is to lay the foundation for the development of an optimal control framework for our state system. The analysis is built upon a recent uniqueness result for the one-dimensional state system. Under suitable assumptions, we focus on the existence of optimal controls and the corresponding necessary optimality conditions.

Existence and Nonlocal-to-Local Convergence for Singular, Anisotropic Nonlocal Cahn-Hilliard Equations

Schedule: July 7 15:00-15:30 Room 740

Yutaka Terasawa

Nagoya University, Japan

Co-Author(s): Helmut Abels

Abstract:

We study the nonlocal-to-local convergence for a nonlocal Cahn-Hilliard equation with anisotropic and singular kernels. In particular, we show convergence of weak solutions of the nonlocal Cahn-Hilliard equation to weak solutions of a corresponding anisotropic Cahn-Hilliard equation for suitable subsequences. Moreover, we show existence of weak solutions for the nonlocal equation under a condition, which guarantees existence of weak solutions for suitably localized or singular kernels. We put a focus on the existence part in the talk. This is based on a joint work with Helmut Abels (Regensburg Univ.).

Cahn-Hilliard equation associated with hypergraph Laplacian

Schedule: July 6 16:30-17:00 Room 740

Shun Uchida

Oita University, Japan

Abstract:

In this talk, we consider the solvability of a multi-valued nonlinear ODE system obtained by replacing the Laplacian of the Cahn-Hilliard equations with a hypergraph Laplacian. The hypergraph Laplacian is a nonlinear multi-valued operator introduced to analyze complex network structures. In previous studies, it is known that solutions to evolution equations with this operator behave similarly to that of the heat equation. By analogy with the Cahn-Hilliard equations, we can expect that the system we consider represents a multi-phase decomposition in a discrete domain. However, due to the nonlinearity and multi-valuedness of the hypergraph Laplacian, standard methods for the Cahn-Hilliard equations can not be applied. In this talk, we will introduce a new proof method by using properties of the hypergraph Laplacian.

Optimal Control of a Navier-Stokes-Cahn-Hilliard System for Membrane-fluid Interaction

Schedule: July 6 18:00-18:30 Room 740

HAO WU

Fudan University, Peoples Rep of China

Co-Author(s): Andrea Signori, Hao Wu

Abstract:

We consider an optimal control problem for a two-dimensional Navier-Stokes-Cahn-Hilliard system arising in the modeling of fluid-membrane interaction. The fluid dynamics is governed by the incompressible Navier-Stokes equations, which are nonlinearly coupled with a sixth-order Cahn-Hilliard type equation representing the deformation of a flexible membrane through a phase-field variable. We introduce an external forcing term acting on the fluid as the control variable. Then we seek to minimize a tracking-type cost functional, demonstrating the existence of an optimal control and deriving the associated first-order necessary optimality conditions.

Special Session 88 : Diffusion problems with non-standard growth conditions

Organizer(s): Gabriella Zecca , Stefano Buccheri

Introduction: This session aims to address the recent results on parabolic problems related to partial differential equations appearing in the mathematical models of diffusion processes where traditional assumptions about growth conditions do not hold, leading to more complicate nonlinear behaviors. Such problems arise in various scientific and engineering fields, including materials science, biology, and fluid dynamics. The discussions will focus on the recent advancements in this area and on the analytical techniques for tackling these issues, highlighting the implications of non-standard growth on stability, long-term behavior, existence and regularity of solutions. Recent results for such problems in the stationary context will be also considered. The final aim is to provide a platform to exchange ideas, foster collaborations, and enhance understanding of the new advancements on diffusion phenomena in non-standard contexts, in view of future directions and new developments in this field.

Regularity results for a degenerate double phase type operator with irregular data

Schedule: July 8 8:30-9:00 Room 642

Fessel Achhoud

University of Messina, Italy

Co-Author(s): Rita CIRMI and Salvatore D'ASERO

Abstract:

Our talk deals with the following nonlinear Dirichlet problem associated to the model equation

$$-\operatorname{div}(a(x)|\nabla v|^{p-2}\nabla v) - \operatorname{div}\left(|v|^{q(r-1)+1}|\nabla v|^{q-2}\nabla v\right) = f \quad \text{in } \Omega,$$

where Ω is a bounded open subset of $\mathbb{R}^N$, $N > 2$, $1 < q < p \frac{1}{q'}$, f is a function with poor summability and the function $a(x)$ is a measurable function such that $\alpha \leq a(x) \leq \beta$, a.e. $x \in \Omega$ with $\alpha, \beta > 0$. Previous results showed that, even for $f \in L^1 \log L^1(\Omega)$, the presence of the degenerate term $-\operatorname{div}(|v|^{q(r-1)+1}|\nabla v|^{q-2}\nabla v)$ yields a strong regularizing effect, ensuring existence and improved regularity of distributional solutions. Building on that, we extended this result to the case where the datum $f \in L^m(\Omega)$, with $m > 1$, including the regime $1 < m < (p^*)'$. Furthermore, we addressed a new borderline case, obtaining existence results in the space $W^{1,1}_0(\Omega)$. These findings highlight the crucial role played by degenerate gradient terms in overcoming the lack of regularity of the data.

Existence and regularity results for a class of singular parabolic problems with L^1 data

Schedule: July 8 9:00-9:30 Room 642

Ida de Bonis

Sapienza University of Rome, Italy

Abstract:

We prove existence and regularity results for a class of parabolic problems with irregular initial data and lower order terms singular with respect to the solution. We prove that, even if the initial datum is not bounded but only in $L^1(\Omega)$, there exists a solution that "instantly" becomes bounded. The results are obtained in collaboration with M.M. Porzio.

Nonlinear elliptic problems with quadratic gradient growth and singular Robin eigenvalues

Schedule: July 8 9:30-10:00 Room 642

Francesco Della Pietra

Universita degli studi di Napoli Federico II, Italy

Co-Author(s): Giuseppina di Blasio, Giuseppe Riey

Abstract:

In the talk I will describe an existence result for Robin boundary value problems modeled on

$$\begin{cases} \Delta u + |\nabla u|^2 + \lambda f(x) = 0 & \text{in } \Omega \\ \frac{\partial u}{\partial \nu} + \beta u = 0 & \text{on } \partial\Omega \end{cases}$$

where Ω is a bounded, sufficiently smooth open set in $\mathbb{R}^N$, $f(x)$ belongs to the Marcinkiewicz space $M^{\frac{N}{2}}$ and $\{\beta > 0\}$, under a smallness assumption on the datum λ . In order to study such problem, I will show several properties of the weighted, singular Robin eigenvalue problem

$$\lambda_{1,f,\gamma}(\Omega) = \inf_{\psi \in H^1, \int_{\Omega} f \psi^2 = 1} \left\{ \int_{\Omega} |\nabla \psi|^2 dx + \gamma \int_{\partial\Omega} \psi^2 \right\}.$$

Recent developments on noncoercive anisotropic operators with singular lower order terms

Schedule: July 8 14:30-15:00 Room 642

Giuseppina di Blasio

University of Campania "L. Vanvitelli", Italy

Abstract:

The aim of this talk is to provide an overview of several results obtained in recent years concerning a class of noncoercive anisotropic elliptic equations. We focus on problems where the presence of a convection term characterized by coefficients belonging to suitable Marcinkiewicz spaces, leads to a loss of coercivity in the associated differential operator. In this talk, starting from the classical results, I will illustrate the most recent developments achieved in collaboration with F. Feo and G. Zecca, trying to provide an overview of the current state of the art on this topic.

Schiffer type problems on the plane and the 2-sphere.

Schedule: July 8 15:00-15:30 Room 642

Antonio J. Fernández

Universidad Autónoma de Madrid, Spain

Abstract:

The so-called Schiffer conjecture can be stated as follows: If a nonconstant Neumann eigenfunction of the Laplacian on a smooth bounded domain is constant on the boundary, then the domain is a ball. In this talk we will consider two slightly relaxed versions of this conjecture, and provide suitable counterexamples to them. Specifically, we will consider annular type domains on the plane, and spherical cap type domains on the 2-sphere. The proofs rely on a local bifurcation argument. We combine the use of anisotropic Hölder spaces for the functional setting with computer-assisted techniques to check the bifurcation conditions. The talk is based on joint works with A. Enciso, D. Ruiz and P. Sicbaldi (planar case), and with G. Cao-Labora (2-sphere case).

Quasilinear elliptic systems with critical growth

Schedule: July 8 14:00-14:30 Room 642

Luigi Greco

Università di Napoli, Italy

Abstract:

We study the Dirichlet problem for nonlinear elliptic systems of convection-diffusion type with singular coefficients in the convective term. Our operators are monotone, with principal part of p -Laplacian type, satisfy appropriate ellipticity conditions and have critical growth. This may produce lack of coercivity and compactness. We extend to systems results already proven for the scalar case. To treat the vectorial case, we need an additional structural condition. We discuss some of these conditions, which are inspired by the well-known Landes' condition. Our results are contained in a joint work with Gabriella Zecca.

Periodic solutions to the Lorentz force equation

Schedule: July 8 15:30-16:00 Room 642

Salvador López Martínez

Autonomous University of Madrid, Spain

Co-Author(s): Manuel Garzón

Abstract:

The motion of a charged particle in an electromagnetic field is governed by the Lorentz force equation (LFE), a classical model independently introduced by Poincaré and Planck in the early twentieth century. It has been known since then that the periodic solutions -- corresponding to particles traveling in closed orbits -- can be formally obtained as critical points of the relativistic action functional. However, the action functional becomes nonsmooth as the speed of the particle approaches the speed of light. Thus, a rigorous critical point theory for the nonsmooth action functional has only recently been developed. In this talk, I will present some recent advances in the variational study of the LFE in collaboration with Manuel Garzón (ICMAT, Madrid).

The regularizing effect of superlinear terms in Elliptic and Parabolic Equations

Schedule: July 8 8:00-8:30 Room 642

Martina Magliocca

Universidad de Sevilla, Spain

Abstract:

We will discuss the regularizing effect induced by superlinear terms in some class of Elliptic and Parabolic Equations. Our model equations are
$$\begin{cases} u_t - \Delta u = g(u)|\nabla u|^q + f & \text{in } (0,T) \times \Omega, \\ \end{cases}$$
 and
$$\begin{cases} -\Delta u = g(u)|\nabla u|^q + f & \text{in } \Omega, \end{cases}$$
 being $\Omega \subset \mathbb{R}^N$ for $N \geq 2$, $g(u) > 0$ and $q < 2$. We assume that the term $g(u)|\nabla u|^q$ behaves in a superlinear way. Roughly speaking, if $g(u) \equiv \text{const.}$, then we are asking for $1 < q < 2$. In the more general case $g(u) \not\equiv \text{const.}$, the q threshold is influenced by this perturbation term and the superlinear q range depends on its growth. An important remark on this kind of problems concerns the data assumptions, which have to satisfy well precises compatibility conditions in order to have existence of solutions. We will show that, under certain growth assumptions on $g(u)$, we can relax the regularity needed on the data w.r.t. the case $g(u) = \text{const.}$.

Singular elliptic equations having a gradient term with natural growth

Schedule: July 8 17:30-18:00 Room 642

Anna Mercaldo

University of Naples Federico II, Italy

Abstract:

This talk will present existence results for a class of homogeneous Dirichlet boundary value problems for equations whose prototype is

$$-\Delta_p u = h(u)|\nabla u|^p + u^{q-1} + f(x) \quad \text{in } \Omega,$$

where Ω an open bounded subset of $\mathbb{R}^N$, 0

 L^∞ estimates for a class of nonlinear elliptic systems with nonstandard growth

Schedule: July 8 16:30-17:00 Room 642

Antonella Nastasi

University of Palermo, Italy

Co-Author(s): Elvira Mascolo (University of Florence) and Cintia Pacchiano Camacho (Calgary University).

Abstract:

The talk shall focus on energy integral functionals of the form

$$\int_{\Omega} F(x, Du) \, dx,$$

where the integrand is characterized by nonstandard growth conditions with respect to the gradient. We prove the local boundedness of solutions of partial differential systems in divergence form. The systems under consideration include the first variations of functionals depending on the space variable and having nonstandard growth with respect to the gradient, like for instance the model with growth depending on the point, but without assuming the usual Δ_2 condition. The results are part of a joint project with Elvira Mascolo (University of Florence) and Cintia Pacchiano Camacho (Calgary University).

Fractional capacitary potentials at the critical threshold: decay, breakdown, and vanishing capacity

Schedule: July 8 13:30-14:00 Room 642

Giampiero Palatucci

University of Parma, Italy

Co-Author(s): Matteo Focardi; Caterina Ida Zeppieri

Abstract:

The p -fractional capacitary problem provides a natural nonlocal counterpart of classical capacity for arbitrary compact sets. A central issue is the behavior at infinity of the associated equilibrium potentials and its relation with the scaling of the energy. In this talk I will first discuss the decay at infinity in the subcritical regime. I will then turn to the critical threshold, where the picture changes dramatically. I will show that the corresponding fractional capacity vanishes, revealing a sharp degeneracy of the critical regime. This contrast highlights the special role of the threshold case and the need for a different potential-theoretic perspective at criticality.

The asymptotic behavior of Quasilinear CalderOn problem w.r.t. the boundary data

Schedule: July 8 17:00-17:30 Room 642

Gianpaolo Piscitelli

Universita' degli studi di Napoli Parthenope, Italy

Co-Author(s): A. Corbo Esposito, L. Faella, V. Mottola, G. Piscitelli, R. Prakash, and A. Tamburrino

Abstract:

We consider a quasilinear version of the Calderon problem on a region which, at a given point in the space, present a behavior for large (or small) arguments that is described by monomials of order p and q . The original contribution works [1,2] make is that the nonlinear problem can be approximated by a weighted p -Laplace problem. From the perspective of tomography, this is a significant result because it highlights the central role played by the p -Laplacian in inverse problems with nonlinear materials. Moreover, when $p = 2$, this provides a powerful bridge to bring all the imaging methods and algorithms developed for linear materials into the arena of problems with nonlinear materials. The main result of [1,2] is that for "large" or "small" Dirichlet data in the presence of two materials of different order (i) one material can be replaced by either a perfect electric conductor or a perfect electric insulator and (ii) the other material can be replaced by a material giving rise to a weighted p -Laplace problem. [1] A. Corbo Esposito, L. Faella, G. Piscitelli, R. Prakash, and A. Tamburrino, The p -Laplace "signature" for Quasilinear Inverse Problems with Large boundary data, SIAM Journal on Mathematical Analysis, 56 (2024), pp. 275-303. [2] A. Corbo Esposito, L. Faella, V. Mottola, G. Piscitelli, R. Prakash, and A. Tamburrino, The p_0 -laplace "signature" for Quasilinear Inverse Problems, SIAM J. Imaging Sci., 17 (2024), pp. 351-388.

Special Session 89 : Partial Differential Equations: Diverse Applications and Connections

Organizer(s): Patrizia Di Gironimo , Marta Macrì , Sara Monsurro

Introduction: This special session aims to bring together experts in various aspects of PDEs to promote ideas exchange and potential collaborations. The session will feature conferences on a range of topics including regularity, semigroup theory technique, analytical methods for climate science, probabilistic aspects, and quantum mechanics.

Global boundedness of solutions to fully anisotropic variational problems

Schedule: July 6 15:30-16:00 Room 314

Angela Alberico

Italian National Research Council - Institute for Applied Calculus (Napoli), Italy

Abstract:

A class of nonlinear, fully anisotropic variational problems whose anisotropy is governed by a general n -dimensional convex function of the gradient is analyzed. Global boundedness for both solutions to fully anisotropic nonlinear elliptic Dirichlet problems, and minima of fully anisotropic variational integrals, is established under general growth conditions, not necessarily of power type. The results unify and extend several existing contributions in the literature, yielding new regularity conclusions across a variety of anisotropic frameworks.

Finite energy solutions for a class of Dirichlet problem with very singular data

Schedule: July 6 14:00-14:30 Room 314

Giuseppa Rita Cirmi

University of Catania, Italy

Co-Author(s): Lucio Boccardo, Gustavo Madeira

Abstract:

We study the homogeneous Dirichlet problem for a class of nonlinear elliptic equations of the form: $-\operatorname{div}([a(x) + |u|^\theta] |\nabla u|^{p-2}) = f$ in Ω , where Ω is a bounded open set in $\mathbb{R}^N$ ($N > 2$), $1 < p < N$, and $\theta > 0$. The coefficient matrix $a(x)$ is assumed to be elliptic with bounded entries, while the source term f satisfies minimal summability assumptions. We prove the existence of finite energy solutions, highlighting how the results depend on both the summability of f and the value of the parameter θ . Furthermore, we discuss the existence of $W_0^{1,1}(\Omega)$ solutions for small values of θ and for p close to 1.

On the existence of $W_0^{1,1}$ distributional solutions to nonlinear elliptic equations with lower-order terms.

Schedule: July 6 14:30-15:00 Room 314

Salvatore D'Asero

University of Catania, Italy

Abstract:

We study the existence of distributional solutions in $W_0^{1,1}$ for nonlinear elliptic equations with lower-order terms and possibly singular right-hand side terms.

On the Obstacle Problem for Nonlinear Materials via the Monotonicity Principle

Schedule: July 7 9:00-9:30 Room 314

Luisa Faella

University of Cassino and Southern Lazio, Italy

Co-Author(s): Antonio Corbo Esposito, Vincenzo Mottola, Gianpaolo Piscitelli, Ravi Prakash, Antonello Tamburrino

Abstract:

In this talk, we discuss the Monotonicity Principle (MP) for nonlinear materials with piecewise growth exponents. This setting is particularly relevant for applications, as it enables the use of fast imaging methods based on the MP in problems involving multiple materials, at least one of which exhibits nonlinear behavior. The proposed framework is quite general and can accommodate a variety of practical configurations, including Superconducting (SC), Perfect Electric Conducting (PEC), and Perfect Electric Insulating (PEI) materials. A central role is played by the average Dirichlet-to-Neumann operator. We show how this approach can be extended to the more general setting.

Boundedness of Weak Solutions for a Degenerate Elliptic Equation Modelling Spider Orb Webs

Schedule: July 6 15:00-15:30 Room 314

Maria Stella Fanciullo

Università degli Studi di Catania, Italy

Co-Author(s): Giuseppe Di Fazio, Antonino Morassi, Pietro Zamboni

Abstract:

We present a boundedness result for weak solutions to a class of two-weight degenerate elliptic equations. The motivating example is the equation governing the static equilibrium of a spider orb web, whose continuous membrane model was proposed by Morassi, Soler and Zaera in 2017. The concentration of radial threads near the center induces a singularity at the origin. This is reflected in the degenerate character of the equation of the model through two weights whose ratios are neither bounded away from zero nor bounded from above. Our approach combines a refined two-weight Sobolev-Poincaré inequality with the assumption that lower-order coefficients belong to a generalized Stummel-Kato class. These tools, together with a generalized Moser iteration scheme, yield an explicit L^∞ bound for weak solutions in terms of the data and the weights.

Asymptotic Behavior and Blow-up Analysis for Parabolic Obstacle Problems with Drifts

Schedule: July 6 17:30-18:00 Room 314

Fernando Farroni

Università degli Studi di Napoli Federico II, Dipartimento di Matematica e Applicazioni R. Caccioppoli, Italy

Abstract:

We study the evolution for a class of parabolic obstacle problems. The aim of this talk is two-fold. For global-in-time solutions, we describe the large-time behavior. For solutions defined on bounded time horizons, we perform a blow-up analysis.

Noncoercive Parabolic Systems

Schedule: July 6 16:30-17:00 Room 314

Luigi Greco

Università di Napoli, Italy

Abstract:

We prove existence results for the Cauchy-Dirichlet problem for convection-diffusion parabolic systems with singular coefficients in the convective term. The principal part of our operator is of p -Laplacian type and standard monotonicity and growth conditions are assumed. However, the coefficients of the lower order terms are time dependent and belong to borderline mixed Lebesgue-Marcinkiewicz spaces, and this causes lack of coercivity. We are not assuming any additional structure condition, such as for example the well-known Landes condition, introduced to deal with systems. We also show optimality of our results in the linear case.

BV functions, hyperbolic conservation laws and fractal sets

Schedule: July 7 9:30-10:00 Room 314

Emanuel Guariglia

Kean University, Italy

Abstract:

In this talk, we review some important results on the uniqueness of solutions to hyperbolic conservation laws. More precisely, we show that every weak solution taking values in the domain of the semigroup, and such that shocks satisfy the Liu conditions, coincides with a semigroup trajectory. Finally, we give an application in fractal geometry.

Isoperimetric Inequalities for a Capillarity Problem

Schedule: July 6 13:30-14:00 Room 314

Giulio Pascale

Università degli Studi di Napoli Federico II, Italy

Abstract:

The classical capillarity problem consists of minimizing, among sets satisfying a volume constraint within a given container, a suitably weighted perimeter. The contribution of the interface that touches the boundary of the container is weighted by a fixed constant representing the relative adhesion coefficient between the liquid drop and the solid walls of the container. When the container is a half-space, the isoperimetric sets for this problem are suitably truncated balls lying on the boundary of the half-space. The aim of this talk is to present some quantitative isoperimetric inequalities for the capillarity problem in a half-space, which estimate different notions of asymmetry of a competitor with respect to the optimal bubble in terms of the corresponding isoperimetric deficit. I will also mention some applications in which nonlocal interactions are taken into account.

Behavior of the solutions to nonlinear parabolic equations with absorption terms

Schedule: July 7 8:30-9:00 Room 314

Maria Michaela MM Porzio

Sapienza University of Rome, Italy

Abstract:

In this talk we discuss the influence of an absorption term of power type on the regularity and time behavior of the solutions to a class of nonlinear parabolic problems. We will show that important and unexpected changes occur. For example, in absence of a forcing term it can produce an immediate boundedness in cases when it is well known that, in absence of such a lower order term, the solutions remain unbounded. Moreover, we prove that regularization phenomena appear also in presence of forcing terms.

Higher differentiability for solutions to a class of elliptic systems with lower order terms

Schedule: July 6 18:00-18:30 Room 314

Teresa Radice

University of Naples Federico II, Italy

Co-Author(s): Fernando Farroni

Abstract:

This talk concerns the higher differentiability of the solution u to the Dirichlet problem:
$$\begin{cases} \operatorname{div} (A(x, Du)) + B(x, u) = f & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega \end{cases}$$
 on a bounded Lipschitz domain Ω in $\mathbb{R}^n$. The lower order term $B(x, u)$ is controlled with respect to spatial variable by a function $b(x)$ belonging to the Marcinkiewicz space $L^{n, \infty}$. This work is in collaboration with Fernando Farroni.

Sobolev embeddings and divergence operator

Schedule: July 6 17:00-17:30 Room 314

Roberta Schiattarella

Dipartimento di Matematica e applicazioni, Università degli Studi di Napoli Federico II, Italy

Co-Author(s): Gianluigi Manzo

Abstract:

We investigate the relationship between Sobolev-type embeddings and the solvability of the divergence equation $\operatorname{div} u = f$ in the setting of Banach function spaces. Given two spaces $X, Y \subset L^1(Q_0)$ where $Q_0 = [0, 1]^n$, we denote by $\mathbf{Y}$ the space of vector fields whose components belong to Y , and by X', Y' their associate spaces. We show that the existence of solutions $u \in \mathbf{Y}$ to $\operatorname{div} u = f$ for every $f \in X$ is equivalent to a dual Sobolev embedding of the form

$$W_0^1 Y' \hookrightarrow X'.$$

This establishes a general duality principle linking divergence-type equations and Sobolev embeddings beyond the classical Lebesgue framework. We also present examples highlighting borderline phenomena, where standard regularity and gradient representation fail. This work is based on a joint project with Gianluigi Manzo.

Existence and Qualitative Properties of Solutions for a Class of Nonlinear Fokker-Planck Equations with Superlinear drift

Schedule: July 7 8:00-8:30 Room 314

Gabriella Zecca

Dipartimento di Matematica e Applicazioni "R. Caccioppoli" - Università degli Studi di Napoli Federico II, Italy

Co-Author(s): Stefano Buccheri, Fernando Farroni

Abstract:

In this talk, I will deal with a class of nonlinear Fokker-Planck equations with the following structure:
$$\partial_t u - \operatorname{div}(M \nabla u + E h(u)) = 0,$$
 where M is a bounded elliptic matrix, E is a vector field in a suitable Lebesgue space, and $h(u)$ exhibits a superlinear growth. I will provide existence results for $C([0, T], L^1)$ distributional solutions to initial-boundary value problems related to the above equation under general assumptions on the coefficients. The approach followed is entirely non-variational, does not require specific structural assumptions on the vector field E (such as being a gradient), and avoids the use of representation formulas. Additionally, some qualitative properties of the solutions will be discussed. These results have been obtained in collaboration with Stefano Buccheri and Fernando Farroni.

Special Session 90 : NONLINEAR ELLIPTIC DIFFERENTIAL EQUATIONS AND APPLICATIONS

Organizer(s): Antonia Chinni , Maria-Magdalena Boureau , Beatrice Di Bella

Introduction: The aim of this Special Session is to outline the recent advances on topics in the field of nonlinear elliptic equations. We focus on existence, multiplicity and qualitative properties of solutions of nonlinear differential problems involving also operators depending on variable exponent, double phase operators and with convection term. Emphasis is put on variational techniques, combined with topological arguments and sub-super-solution methods.

Polynomial-type operators that preserve logarithmic functions

Schedule: July 7 16:30-17:00 Room 438

Laura Angeloni

Department of Mathematics and Computer Science, University of Perugia, Italy

Co-Author(s): Danilo Costarelli, Chiara Darielli

Abstract:

In this talk we will present some approximation results by means of a new class of polynomial-type operators that generalize the classical Bernstein polynomials and preserve a logarithmic function. The starting point are the Bernstein-type exponential polynomials introduced by Aral, Cardenas-Morales and Garrancho in 2018 and the main idea is to replace the exponential weights by means of logarithmic ones. For such operators we first establish pointwise and uniform convergence as well as their relation with the classical King operators. This allows us to obtain a quantitative estimate of the approximation error and a Voronovskaja-type asymptotic result. By means of this formula, we obtain saturation results and inverse theorems. In particular, by the Voronovskaja formula, a second order differential operator naturally arises: the set of the solutions of the corresponding homogeneous ODE represents the saturation class of the considered operators. Some shape preserving properties are also discussed.

Asymptotic analysis of elastic elliptic membrane shells in adhesive contact

Schedule: July 7 9:00-9:30 Room 438

W Angel D Arros Rodríguez

CITMaga, Universidade da Coruña, Spain

Abstract:

By using asymptotic analysis arguments, we derive and justify a two-dimensional contact model for linearly elastic elliptic membrane shells in adhesive contact with a deformable foundation. The process is assumed to be quasistatic, and therefore the effects of inertia are neglected. Contact is modeled with normal compliance and the adhesion is modeled by introducing a surface auxiliary variable, the bonding function, the evolution of which is described by a nonlinear first order differential equation. To do this, we consider the three-dimensional contact problem, introduce a change of variable to curvilinear coordinates, together with the right scaling of the unknowns and parameters of the problem, and when the thickness of the shell (small parameter of the problem) tends to zero we obtain a two-dimensional limit model, which we justify with a rigorous convergence theorem. We will also show a fully discrete numerical scheme and results of some numerical simulations to test the performance of our model.

On the sub and supersolution method for nonlinear elliptic equations with a convective term.

Schedule: July 7 17:30-18:00 Room 438

Giuseppina G. Barletta

University of Reggio Calabria, Italy

Co-Author(s): E. Tornatore

Abstract:

We present some existence (with also sign information) and regularity results for differential equations, in which the method of sub and supersolutions plays an important role. We focus on Dirichlet problem, for problems driven by a general differential operator, depending on $(x, u, \nabla u)$, and with a convective term f . Our framework is that of Orlicz-Sobolev spaces. We present also several examples.

On the Well-posedness of Problems with Fixed Point Structure

Schedule: July 7 9:30-10:00 Room 438

Pasquale Candito

University of Palermo, Italy

Co-Author(s): Bruno Vassallo Mircea Sofonea

Abstract:

Let X and Y be two arbitrary sets, $P \subset X \times Y$ and $S : X \rightarrow Y$. We consider the problem of finding an element $u \in X$ such that $(u, Su) \in P$. We prove that the existence of the solution to this problem is obtained, provided that an associated operator Λ has a fixed point. Moreover, under an additional assumption, the solution is unique if and only if the fixed point is unique. Then, in the framework of metric spaces X and Y , we provide necessary and sufficient conditions for the convergence of an arbitrary sequence $\{u_n\} \subset X$ to the solution u . We also show some applications of our results in the study of nonlinear boundary value problems for partial differential equations.

On a Hinged Plate Equation: Paradoxes, Existence and Uniqueness

Schedule: July 7 14:00-14:30 Room 438

Cristian P Danet

University of Craiova, Romania

Co-Author(s): Cristian-Paul Danet

Abstract:

Although fourth-order problems have granted attention even from the first decade of the 20th century, most of the literature deals with the Navier case or with Dirichlet boundary conditions, where Green's function arguments are available. This talk is a contribution to the study of a hinged plate problem, i.e., we work under the more complicated boundary conditions called Steklov conditions. Such problems have been studied only in the last decade. Here, we mainly focus on some paradoxes (Babuska and Sapodzyan), existence via variational methods in the case of a semilinear biharmonic Steklov problem and on an uniqueness result based on a maximum principle.

Nonhomogeneous degenerate quasilinear problems with convection and intrinsic operator

Schedule: July 7 14:30-15:00 Room 438

Tornatore Elisabetta

University of Palermo, Italy

Abstract:

A sub-supersolution method is used in the case of a quasilinear Dirichlet problem which exhibits convection, with an intrinsic operator, and whose principal part contains an unbounded coefficient $G(u)$ depending on the solution u . In particular a truncation technique leading to a priori estimates is developed, not only for the reaction term in the equation, but also for the unbounded coefficient. A different truncation method is used to study a Dirichlet problem whose equation is driven by a degenerate p -Laplacian with a weight depending on x and on the solution and whose reaction term is a convection term. The existence of solutions is obtained together with uniform boundedness of the solution set. Joint work with professors D. Motreanu and R. Livrea

Nonlocal Carrier's Double Phase Problem

Schedule: July 7 15:00-15:30 Room 438

Giuseppe Failla

University of Palermo, Italy

Co-Author(s): Leszek Gasiński

Abstract:

We investigate the existence and multiplicity of positive bounded solutions for a class of nonlocal, non-variational elliptic problems driven by a non-homogeneous operator with unbalanced growth, namely the double phase operator. The problem is characterized by the presence of a sign-changing weight function on the left-hand side. Our approach combines several techniques, including the sub- and super-solutions method, variational and truncation techniques, as well as tools from set-valued analysis. Furthermore, we analyze an associated one-dimensional fixed-point problem that allows us to prove the existence of $K > 0$ pairs of positive solutions.

On the Well-posedness of Minimization Problems

Schedule: July 7 8:00-8:30 Room 438

Mircea Sofonea

University of Perpignan, France

Co-Author(s): Mircea Sofonea and Bruno Vassallo

Abstract:

We consider a minimization problem $\mathcal{P}$ in a reflexive Banach space for which we introduce the concept of $\mathcal{T}$ -well posedness. It is based on a new mathematical object, the so-called Tykhonov triple, and it extends the classical Tykhonov and Levitin-Polyak well-posedness concepts. We provide several examples and counter-examples, then we state and prove various well-posedness results. The proofs are based on convexity, compactness and lower semicontinuous arguments. We also discuss the problem of describing an optimal $\mathcal{T}$ -well-posedness concept. Next, we consider the case of differentiable functionals defined on a real Hilbert space. Under additional assumptions, we prove a convergence criteria, that is, we state necessary and sufficient condition that guarantee the convergence of any arbitrary sequence to the solution of problem $\mathcal{P}$, assumed to be unique. We apply these abstract results to prove the convergence of the solution of a penalty problem to the solution of the original minimization problem, as the penalty parameter converges to zero.

Well-posedness Analysis of a Unilateral Contact Problem

Schedule: July 7 8:30-9:00 Room 438

Bruno Vassallo

University of Messina, Italy

Co-Author(s): Roberto Livrea and Mircea Sofonea

Abstract:

We consider a mathematical model that describes the equilibrium of a nonlinear elastic membrane which can arrive in contact with a rigid obstacle, the so-called foundation. The membrane is fixed on its boundary, is acted upon by a vertical force, the contact is frictionless and is modelled with the well-known Signorini boundary condition. The novelty is that we model the material's behaviour with a Hencky-type elastic constitutive law and, therefore, the problem is governed by a p -Laplacian operator. Using such a constitutive assumption makes the model nonstandard from a mechanical point of view and challenging from a mathematical point of view. We use a Weierstrass-type minimization argument to prove the unique weak solvability of the model. Then, we turn to the well-posedness analysis of the problem, which represents the main novelty of this manuscript. Thus, we introduce three well-posedness concepts, compare them and state and prove strong and weak well-posedness results. We also discuss the problem of finding an optimal well-posedness result. Finally, we apply these results to prove that the solution depends continuously with respect to the density of applied forces and the initial gap. We end our paper with an Appendix in which we present some preliminary results used in this manuscript.

Quasi-linear fractional Wentzell problems

Schedule: July 7 17:00-17:30 Room 438

Alejandro Velez-Santiago

University of Puerto Rico - Rio Piedras Campus, USA

Co-Author(s): Efren Mesino-Espinosa

Abstract:

We investigate a generalized quasi-linear elliptic boundary value problem governed by the regional fractional p -Laplacian $(-\Delta)_{p,\Omega}^s$ in Ω , and generalized fractional Wentzell boundary conditions of type

$$C_{p,s}' \mathcal{N}^{p'(1-s)} u + \beta |u|^{q-2} u + \Theta_q^\eta u = g \text{ on } \Gamma,$$

where Θ_q^η stands as a nonlocal fractional-type q -operator on Γ (also referred as a Besov q -map), $C_{p,s}' \mathcal{N}^{p'(1-s)}$ denotes the fractional p -normal derivative operator in Γ , and p, q are two exponents on the interior and boundary, respectively (which are in general unrelated between each other). We first show that this model equation admits a unique weak solution, which is globally bounded in $\overline{\Omega}$. Furthermore, a priori L^∞ -estimates for the difference of weak solutions are provided, with upper bound depending in the differences of the respective interior and boundary data functions. Additionally, a Weak Comparison Principle is derived, and we conclude by establishing a sort of nonlinear Fredholm Alternative related to this generalized elliptic fractional model equation.

Special Session 91 : Geometric evolution problems

Organizer(s): James McCoy , Yong Wei

Introduction: The theory and application of geometric evolution equations is a fundamental area of mathematical research internationally, with widespread applications to other areas of mathematics, including topology and convex geometry, and beyond mathematics, to models including in physics and engineering. This session aims to bring together key researchers in intrinsic (metric) and extrinsic (hypersurface) flows to share the latest developments in the field and foster new collaborations that will drive important new research directions into the future.

Analysis of Critical Points of Conformally Invariant Curvature Energies in 4d

Schedule: July 7 16:30-17:00 Room 822

Yann Bernard

Monash University, Australia

Co-Author(s): Tian Lan, Dorian Martino, Tristan Riviere

Abstract:

We consider the Euler--Lagrange equations satisfied by the critical points of a large class of conformally invariant extrinsic energies for 4-manifolds immersed into Euclidean space. Using invariances and Noether's theorem, we convert the Euler--Lagrange equation into a system of equations with analytically favourable structures, and we develop small-energy estimates. This generalises to the four-dimensional setting ideas originally developed for the Willmore energy in two dimensions.

Degenerate and Singular Fractional Equations and Optimally Embedded Submanifolds

Schedule: July 7 17:30-18:00 Room 822

Simon SB Blatt

University Salzburg, Austria

Abstract:

Over the past three decades, a variety of energy functionals have been developed and analyzed to address the problem of finding optimal embeddings of curves, links, and higher-dimensional submanifolds into Euclidean space. The associated Euler-Lagrange equations give rise to a rich class of geometric non-local differential equations, encompassing degenerate elliptic, singular, critical, and subcritical types. In this talk, we will provide a concise overview of the state of the art in this field, highlighting key results, challenges, and open questions

Classifying ancient solutions in mean curvature flow

Schedule: July 7 14:00-14:30 Room 822

Beomjun Choi

KAIST, Korea

Abstract:

Ancient solutions play a central role in mean curvature flow, since they often arise as blow-up models near singularities. This leads to a natural program: by classifying ancient solutions, one hopes to organize the possible local pictures of singularity formation. In this talk, I will give an introduction to this viewpoint and describe several recent classification results, focusing in particular on ancient ovals and related rigidity phenomena in higher dimensions. I will also explain how such results fit into the broader effort to understand singularities through canonical models.

Integral curvature bounds and Perelman's bounded diameter conjecture for Type I Ricci flows

Schedule: July 7 13:30-14:00 Room 822

Panagiotis Gianniotis

National and Kapodistrian University of Athens, Greece

Co-Author(s): Konstantinos Leskas

Abstract:

Given a smooth Ricci flow that becomes singular in finite time, a k -neck regions is a region of the manifold in which the flow is almost self-similar and almost splits k Euclidean factors, down to arbitrarily small scales. Neck regions are characterized by a set of centres which can be thought of as a discrete approximation of high curvature regions. In this talk we will describe how, under a Type I curvature bound, we can effectively control the k -dimensional size of the set of centres, by carefully analyzing the behaviour of almost splitting maps at small scales. As an application, we will see how such a result implies Perelman's bounded diameter conjecture for a 3d Ricci flow exhibiting Type I singularities. In higher dimensions, it can be used to obtain the optimal L^1 curvature bound in higher dimensions, in joint work with Konstantinos Leskas.

Rigidity of minimal and CMC hypersurfaces.

Schedule: July 7 15:30-16:00 Room 822

Han Hong

Beijing Jiaotong University, Peoples Rep of China

Abstract:

This talk will present a broad overview of rigidity results for stable and finite-index minimal (or constant mean curvature) surfaces. We will survey key milestones in the field, including the stable Bernstein problem for minimal hypersurfaces, its capillary surface analogue, do Carmo's problem for non-minimal CMC hypersurfaces, and rigidity theorems for stable minimal hypersurfaces in general Riemannian manifolds. The presentation will focus on the statements of these results and their geometric significance, without delving into the technical details of the proofs.

Capillary Christoffel-Minkowski problem

Schedule: July 7 17:00-17:30 Room 822

Yingxiang Hu

Beihang University, Peoples Rep of China

Co-Author(s): Mohammad N. Ivaki (TU Wien) and Julian Scheuer (Goethe University Frankfurt)

Abstract:

The result of Guan and Ma (Invent. Math. 151 (2003)) states that if $\phi^{-1/k} : \mathbb{S}^n \rightarrow (0, \infty)$ is spherically convex, then ϕ arises as the σ_k curvature (the k -th elementary symmetric function of the principal radii of curvature) of a strictly convex hypersurface. We establish an analogous result in the capillary setting in the half-space for $\theta \in (0, \pi/2)$: if $\phi^{-1/k} : \mathcal{C}_\theta \rightarrow (0, \infty)$ is a capillary function and spherically convex, then ϕ is the σ_k curvature of a strictly convex capillary hypersurface. This is based on joint works with Mohammad N. Ivaki (TU Wien) and Julian Scheuer (Goethe University Frankfurt).

The p -elastic flow of inextensible planar curves

Schedule: July 8 9:30-10:00 Room 822

Chun-Chi Lin

National Taiwan Normal University, Taiwan

Abstract:

In this talk, I will discuss the existence of solutions to the negative L^2 -gradient flow of the p -elastic energy for the class of inextensible planar closed or open curves. For open curves, the boundary conditions correspond to either hinged ends (i.e., zero curvature at their boundaries) or clamped ends (i.e., fixed contact angles at their boundaries). We show the existence of weak solutions to the negative L^2 -gradient flow for $p \in (1, \infty)$.

The conical K\"ahler-Ricci flow and its limit behavior

Schedule: July 7 14:30-15:00 Room 822

Jiawei Liu

Nanjing University of Science and Technology, Peoples Rep of China

Co-Author(s): Xi Zhang

Abstract:

In this talk, I will recall some results on conical K\"ahler-Ricci flow, and then talk about its limit behavior as the cone angle tends to 0. More precisely, as the cone angle tends to zero, the conical K\"ahler-Ricci flow converges to a unique K\"ahler-Ricci flow, which is smooth outside the divisor and admits cusp singularity along the divisor.

Stabilization technique applied on curve shortening flow in $\mathbb{R}^2$ and $\mathbb{R}^3$

Schedule: July 8 8:30-9:00 Room 822

Hayk Mikayelyan

University of Nottingham Ningbo China, Peoples Rep of China

Abstract:

first we apply the stabilization technique, developed by T. Zelenyak in 1960s for parabolic equations, on the curve shortening flow in $\mathbb{R}^2$, and derive a new monotonicity formula with logarithmic terms. Then we use this idea and derive several new monotonicity formulas for the CSF in $\mathbb{R}^3$. All of them share one main feature: the dependence of the ``energy`` term on the angle between the position vector and the plane orthogonal to the tangent vector.

Direction energy method for non-compact mean curvature flows

Schedule: July 7 9:00-9:30 Room 822

Tatsuya Miura

Kyoto Univeristy, Japan

Co-Author(s): Tatsuya Miura

Abstract:

We introduce the direction energy for oriented immersions into Euclidean space in arbitrary dimensions and codimensions. Our main result establishes an exact dissipation identity for the direction energy along complete, proper, oriented mean curvature flows under a mild local-volume bound. We also discuss several geometric applications. This talk is based on joint work with Fabian Rupp (University of Vienna).

Integral Gauss formula and the Poisson equation for the G_2 -Laplacian

Schedule: July 7 15:00-15:30 Room 822

Artem Pulemotov

The University of Queensland, Australia

Co-Author(s): Timothy Buttsworth, Stepan Hudecek, Artem Pulemotov

Abstract:

The study of special holonomy involves a nonlinear second-order operator on differential forms called the G_2 -Laplacian. In the first half of the talk, we will discuss a formula linking this operator to a natural Hodge Laplacian on a hypersurface. This result bears intriguing resemblance to the Gauss--Codazzi equation for the scalar curvature. In the second half, we will explain how our formula provides an integrability condition for the Poisson equation associated with the G_2 -Laplacian in the presence of cohomogeneity one symmetry. Joint work with Timothy Buttsworth (The University of New South Wales) and Stepan Hudecek (The University of Queensland).

On symplectic mean curvature flows

Schedule: July 7 9:30-10:00 Room 822

Jun Sun

Wuhan University, Peoples Rep of China

Abstract:

The symplectic property is preserved under the mean curvature flow in a KE surface, a flow often referred to as the symplectic mean curvature flow. It has been established that no Type I singularity can occur in such a flow. In this talk, we will first collect the known results on symplectic mean curvature flows. Then we will talk about our recent results on singularity analysis for such a flow. This talk is based on joint work with Jingyi Chen, Xiaoli Han and Jiayu Li.

Existence and regularity of multi-phase mean curvature flow in the hyperbolic space

Schedule: July 7 8:30-9:00 Room 822

Yoshihiro Tonegawa

Institute of Science Tokyo, Japan

Co-Author(s): Qing Han, Nan Wu

Abstract:

We report some existence and regularity results on the multi-phase mean curvature flow in the standard hyperbolic space of general dimensions. Under a mild regularity assumption on the initial data, we prove the global-in-time existence and regularity results of the mean curvature flow. In particular, we show that the smoothness of the asymptotic boundary of the mean curvature flow persists for all time if the initial data is smooth. This reveals an interesting time-dependent regularity property different from the static case where the dimension plays an important role.

Uniqueness of self-similar solutions to curvature flows and uniqueness of solutions to isotropic curvature problems

Schedule: July 8 9:00-9:30 Room 822

Xianfeng Wang

Nankai University, Peoples Rep of China

Abstract:

Self-similar solutions play an important role in the study of the asymptotic behaviors of curvature flows, and are closely related to some prescribed curvature problems. In this talk, we discuss the uniqueness of self-similar solutions to some fully nonlinear curvature flows, as well as the uniqueness of solutions to some isotropic curvature problems.

A Heintze-Karcher-type inequality for capillary hypersurfaces in hyperbolic space

Schedule: July 8 8:00-8:30 Room 822

Tailong Zhou

Sichuan University, Peoples Rep of China

Co-Author(s): Yingxiang Hu, Yong Wei, Chao Xia

Abstract:

In this talk we prove a Heintze-Karcher type inequality and a Minkowski type formula for capillary hypersurfaces in hyperbolic space with boundary supported on general totally umbilical hypersurfaces. As an application, we prove an Alexandrov-type theorem for capillary hypersurfaces with constant k th mean curvature supported on totally umbilical hypersurfaces in hyperbolic space.

Special Session 92 : Numerical Methods for SPDEs: Bridging Theory and Applications

Organizer(s): Hakima Bessaih , Erika Hausenblas , Annie Millet

Introduction: Stochastic Partial Differential Equations (SPDEs) have garnered significant attention in recent decades due to their ability to model complex phenomena influenced by randomness across various domains of science and technology. Random perturbations have proven essential for capturing both theoretical behaviors and numerical effects in systems ranging from fluid dynamics to climate models and beyond. This workshop aims to bring together researchers from diverse backgrounds to present and discuss recent advances in the numerical analysis and simulation of SPDEs. Special emphasis will be placed on fostering the participation and collaboration of early-career researchers, providing them with opportunities to engage with leading experts and contribute to this vibrant area of research.

Higher-order discretisation of the stochastic Navier-Stokes equations with additive noise

Schedule: July 7 9:00-9:30 Room 821

Lubomir Banas

Bielefeld University, Germany

Co-Author(s): Dominic Breit, Abhishek Chaudhary, Andreas Prohl

Abstract:

We propose a higher-order time discretization scheme for the stochastic Navier-Stokes equation with additive noise, with convergence order $3/2$ in probability for the velocity and pressure approximations. The construction rests on the reformulation of the Navier-Stokes SPDE as a random PDE, and the use of suitable higher order numerical quadrature rules for the diffusion and the drift part.

Using Feynman diagrams in renormalisation, some new results

Schedule: July 7 8:00-8:30 Room 821

Nils Berglund

IDP, University of Orleans, France

Abstract:

We present new techniques that simplify the combinatorics of Feynman diagrams when renormalising singular SPDEs and computing expectations under their invariant measures. The techniques make use of algebraic methods, in particular a so-called Wick map. We illustrate these methods in the case of the Φ_d^4 model for any, possibly non-integer dimension strictly less than 4. Reference: <https://arxiv.org/abs/2507.03820>

Numerical Study of a Surface Growth Model with Singular Noise

Schedule: July 6 13:30-14:00 Room 821

Dirk Blömker

University of Augsburg, Germany

Co-Author(s): David Buchberger, Johannes Rimmel

Abstract:

We investigate an SPDE for epitaxial thin-film growth. Remarkably, it has been shown that even arbitrarily small space-time white noise, representing fluctuations in the incoming particles, can stabilize the dynamics and prevent hill formation, which is present for less regular noise. In order to see the transition via numerical simulations, we apply a spectral Galerkin approach together with an exponential Euler method to approximate the solution of the regularised SPDE and give rigorous error estimates.

Optimal Control of Fluid Flows

Schedule: July 6 16:30-17:00 Room 821

Fernanda Cipriano

NOVA University Lisbon, Portugal

Abstract:

This talk is devoted to the study of optimal control problems in fluid dynamics. The fluid is assumed to occupy a bounded domain of $\mathbb{R}^d$, $d=2,3$, and may be subject to external Gaussian random forces. Various types of control actions will be considered to achieve a prescribed velocity profile while minimizing the associated cost. Results concerning the existence and uniqueness of optimal solutions will be presented, and appropriate strategies for determining the optimal control will be developed.

Asymptotic error distribution of the Euler method for stochastic differential equations with irregular drifts

Schedule: July 7 14:30-15:00 Room 821

Konstantinos Dareiotis

University of Leeds, England

Co-Author(s): M^{at}e Gerencs^{er}, Khoa L^{^e}

Abstract:

In this talk we will establish a central limit theorem for the Euler-Maruyama scheme approximating multidimensional SDEs with elliptic Brownian diffusion, under very mild regularity requirements on the drift coefficients. When the drift is Hölder continuous, we show that the limiting law of the rescaled fluctuations around the true solution is characterised by the solution of a hybrid Young-Itô differential equation. When the drift has positive Sobolev regularity, this limit is characterised by the solution of a transformed SDE. Our result is an extension of the result of Jacod--Protter (1998) in which SDEs with bounded differentiable coefficients were considered. To compensate for the lack of regularity of the drifts, we utilize the regularization effect from the non-degenerate noise.

Discrete Stochastic Maximal Regularity

Schedule: July 6 17:00-17:30 Room 821

Foivos F Evangelopoulos-Ntemiris

TU DELFT, Netherlands

Co-Author(s): M. Veraar

Abstract:

Maximal L^p -regularity is a central tool in the analysis of deterministic and stochastic parabolic evolution equations, providing a framework for studying nonlinear problems via linearization techniques. In the deterministic case, a discrete-time theory of maximal ℓ^p -regularity was recently developed for numerical schemes, and its equivalence with the continuous-time theory was established. In this talk, I will extend these ideas to the stochastic setting, introducing discrete stochastic maximal ℓ^p -regularity and exploring its connection to the continuous-time counterpart. The talk is based on joint work with Mark Veraar (TU Delft).

Finite Volume scheme for the Heat equation with transport noise

Schedule: July 7 9:30-10:00 Room 821

Ludovic Goudenège

CNRS, France

Co-Author(s): Anne de Bouard, Flore Nabet

Abstract:

We investigate a finite volume scheme for the heat equation perturbed by transport noise, a stochastic forcing that models random advection effects and arises naturally in fluid dynamics. The equation is interpreted in the Stratonovich sense, preserving key structural properties such as energy balance at the continuous level. We introduce a finite volume approximation coupled with an Euler-Maruyama time-splitting discretization with a consistent treatment of the stochastic transport term which is designed to maintain stability and discrete conservation properties. We establish well-posedness of the numerical scheme and prove convergence towards a solution of the stochastic partial differential equation. Finally, numerical experiments illustrate the behavior of the method, highlighting the impact of transport noise on the solution, in particular on its long-time dynamics. These results demonstrate the robustness and effectiveness of the proposed approach for more complex stochastic diffusion models.

Strong convergence rates for stochastic Burgers equations

Schedule: July 7 13:30-14:00 Room 821

Martin Hutzenthaler

University of Duisburg-Essen, Germany

Co-Author(s): Arnulf Jentzen, Felix Lindner, Robert Link, Primož Pusknik

Abstract:

Subject of this talk are strong convergence rates on the whole probability space for explicit full-discrete approximations of stochastic Burgers equations with multiplicative trace-class noise. The nonlinearity of this benchmark SPDE is not globally monotone. Many classical approximation methods do not converge in the strong sense. In this talk we discuss methods which do converge in the strong sense. The key step in the convergence proof are uniform exponential moment estimates for the numerical approximations.

Temporal approximation of semilinear hyperbolic SPDEs with polynomial nonlinearities

Schedule: July 6 14:30-15:00 Room 821

Katharina Klioba

TU Delft, Netherlands

Abstract:

When approximating hyperbolic SPDEs such as the stochastic Schroedinger equation in time, challenges arise due to the lack of regularising behaviour of the underlying semigroup. In this talk, we present convergence rates for time discretization schemes for such equations, where the leading operator is the generator of a C_0 -semigroup. The first main result are optimal bounds for the uniform strong error

$$E_k^\infty := \left(\mathbb{E} \max_{1 \leq j \leq M} \|U(t_j) - U_j\|_X^p \right)^{1/p}$$

on a Hilbert space X for $p \in [2, \infty)$, a time step $k > 0$ and $T = Mk > 0$. Under conditions on the globally Lipschitz nonlinearity and multiplicative noise, we show $E_k^\infty \lesssim \sqrt{k \log(T/k)}$ for a large class of time discretisation schemes. For equations such as Maxwell's or Schroedinger, our results provide the first results known for rational approximations of $(S(t))_{t \geq 0}$ and improve mean-square error estimates to pathwise uniform ones. The second main result concerns polynomially growing nonlinearities and noise, which imposes additional challenges since only a local Lipschitz condition is satisfied. For a tamed exponential Euler scheme, stability and convergence $E_k^\infty \lesssim \sqrt{k}$ are shown under a coercivity assumption using a stochastic Gronwall inequality. This extension of the abstract framework developed in the first part allows to consider, e.g., the nonlinear Schroedinger equation. This is based partly on joint work with Mark Veraar and partly on ongoing work by the author.

Regularization by regular noise: a numerical result

Schedule: July 6 17:30-18:00 Room 821

Chengcheng Ling

University of Augsburg, Germany

Co-Author(s): Ke Song, Haiyi Wang

Abstract:

We study a singular stochastic equation driven by regular noise of fractional Brownian type with Hurst index $H \in (1, \infty) \setminus \mathbb{Z}$ and drift coefficient $b \in \mathcal{C}^\alpha$, where $\alpha > 1 - \frac{1}{2H}$. The strong well-posedness of this equation was first established in [Gerencs'er, 23], a phenomenon known as 'it regularization by regular noise'. In this note, we provide a numerical analysis of the equation. Specifically, we prove that the Euler-Maruyama approximation X^n converges strongly to the unique solution X at rate n^{-1} . Moreover, we show that $n(X - X^n)$ converges in probability to a non-trivial limit as $n \rightarrow \infty$, which confirms that the rate n^{-1} is optimal for this scheme. In this sense, this provides a first-order numerical method for equations with non-Lipschitz drift while still achieving the rate n^{-1} .

Averaging Principle for the 3D Stochastic Primitive Equations

Schedule: July 7 15:00-15:30 Room 821

Vincent R Martinez

CUNY Hunter College & Graduate Center, USA

Co-Author(s): Qu Yuan Lin, Rongchang Liu, Vincent R. Martinez

Abstract:

This talk will present recent results on the 3D stochastic primitive equations. In particular, we show that the system is nearly uniquely ergodic in the sense that the limit resonant system in the infinite rotation limit is uniquely ergodic and the law of the finite rotation system converges in probability to the law of the limit resonant system on any finite time horizon. The passage of limits is facilitated by weak moment bounds, an averaging procedure developed by Flandoli and Mahalov, as well as a stochastic control argument to establish the existence of a spectral gap.

A stochastic interpretation of the Water Waves model

Schedule: July 6 15:00-15:30 Room 821

Antoine Moneyron

Inria Rennes, France

Co-Author(s): Arnaud Debussche, Etienne Memin, Antoine Moneyron

Abstract:

I will present a stochastic interpretation of the Water Waves equations, based on the LU formulation of the irrotational Euler equations, which typically involves transport noises. The model itself is derived first, then the associated shallow water type models are formally inferred by neglecting some terms in the limit of vanishing aspect ratios. Next, I will introduce some numerical schemes associated to the models above, which are intermediate between the deterministic 4th Runge Kutta method and a stochastic Euler Heun method. Eventually, some numerical simulations will be shown to assess the properties of these stochastic wave models.

Nonparametric Estimation of Noise Covariance in Parabolic SPDEs

Schedule: July 7 14:00-14:30 Room 821

Andreas Petersson

Linnaeus University, Sweden

Co-Author(s): Andreas Petersson

Abstract:

We develop an asymptotic limit theory for nonparametric estimation of the noise covariance kernel in linear parabolic SPDEs with additive colored noise, using space-time infill asymptotics. The method employs discretized infinite-dimensional realized covariations and requires only mild regularity assumptions on the kernel to ensure consistent estimation and asymptotic normality of the estimator. On this basis, we construct omnibus goodness-of-fit tests for the noise covariance that are independent of the SPDE's differential operator. Our framework accommodates a variety of spatial sampling schemes and allows for reliable inference even when spatial resolution is coarser than temporal resolution.

Convergence in law for SPDEs with additive noise

Schedule: July 6 14:00-14:30 Room 821

Lluís Quer Sardanyons

Universitat Autònoma de Barcelona, Spain

Abstract:

We consider the quasi-linear stochastic wave and heat equations in $\mathbb{R}^d$ with $d \in \{1, 2, 3\}$ and $d \geq 1$, respectively, and perturbed by an additive Gaussian noise which is white in time and has a homogeneous spatial correlation with spectral measure μ_n . We allow the Fourier transform of μ_n to be a genuine distribution. Let u^n be the mild solution to these equations. We provide sufficient conditions on the measures μ_n and the initial data to ensure that u^n converges in law, in the space of continuous functions, to the solution of our equations driven by a noise with spectral measure μ , where $\mu_n \rightarrow \mu$ in some sense. We apply our main result to various types of noises, such as the anisotropic fractional noise. We also show that we cover existing results in the literature, such as the case of Riesz kernels and the fractional noise with $d = 1$. The talk is based on joint work with Maria Jolis (Barcelona) and Salvador Ortiz (Oslo).

Uniform A Priori Estimates and Compactness for a Stochastic Ferrohydrodynamic system: A Foundation for Numerical Analysis

Schedule: July 6 18:00-18:30 Room 821

Paul Razafimandimby

Dublin City University, Ireland

Co-Author(s): Aristide Ndongmo Ngana

Abstract:

We consider the stochastic Rosensweig system, a complex model for the dynamics of ferrofluids under the influence of a magnetic field and thermal fluctuations. The system couples the Navier--Stokes equations for the fluid velocity with equations for the fluid's magnetization and the magnetic field, leading to a highly nonlinear SPDE with non-convex constraints. This talk presents a compactness and convergence analysis for a bi-layer approximation of the stochastic Rosensweig system: a Bloch--Torrey regularization to handle the magnetization constraint, coupled with a Galerkin approximation for spatial discretization. This approach yields the existence of a global renormalized weak martingale solution to the system. From a numerical analysis perspective, the core contribution is the derivation of a series of uniform a priori estimates that are independent of both the regularization parameter and the Galerkin dimension. These estimates---including bounds on energy, dissipation, and higher-order moments---are precisely the stability estimates required to prove convergence of fully discrete numerical schemes, such as finite element or spectral methods. By establishing these foundational analytical results, this work lays the necessary groundwork for the future development and rigorous error analysis of computational methods for stochastic ferrohydrodynamic flows.

An Allen-Cahn model with jump-diffusion noise for biological damage and repair

Schedule: July 7 15:30-16:00 Room 821

Luca Scarpa

Politecnico di Milano, Italy

Co-Author(s): Andrea Di Primio, Marvin Fritz, Margherita Zanella

Abstract:

We present a stochastic Allen-Cahn equation for the dynamics of biomolecular damage and repair. The system is driven by two noise processes: a multiplicative cylindrical Wiener process, modelling continuous background stochastic fluctuations, and a jump-type noise, modelling the abrupt, localised damage induced by external radiotherapy shocks. The drift of the equation is singular and covers the typical logarithmic Flory-Huggins potential required in phase-separation dynamics. We prove well-posedness of the model in a strong probabilistic sense, analyse its long-time behaviour, and present some simulations to illustrate how it captures fundamental biological phenomena, such as damage clustering, stress-induced topology perturbations, and damage dynamics. The works presented in the talk are based on joint collaborations with Andrea Di Primio (Scuola Normale Superiore, Pisa, Italy), Marvin Fritz (University of Vienna, Austria), and Margherita Zanella (Politecnico di Milano, Italy).

Convex integration on stochastic PDEs

Schedule: July 7 8:30-9:00 Room 821

Kazuo Yamazaki

University of Nebraska-Lincoln, USA

Co-Author(s): Kazuo Yamazaki

Abstract:

Convex integration dates back to the work of Nash and has developed recently as a way to construct non-unique weak solutions to various PDEs. We discuss recent developments on convex integration on stochastic PDEs with examples including the Navier-Stokes equations, surface quasi-geostrophic equations, and others.

Special Session 93 : Local and nonlocal elliptic boundary value problems

Organizer(s): Pasquale Candito , Kanishka Perera , Giuseppe Failla

Introduction: The aim of this session is to provide an overview of new trends in nonlinear boundary value problems driven by local and/or non-local differential operators. A special emphasis will be on the existence and multiplicity results obtained by applying variational, sub-super solution, and topological methods.

Nonlocal elliptic problems involving the Logarithmic Laplacian

Schedule: July 8 14:00-14:30 Room 739

Rakesh Arora

Indian Institute of Technology, Varanasi, India

Co-Author(s): Jacques Giacomoni and Arshi Vaishnavi

Abstract:

This talk presents new sharp continuous and compact embeddings of nonlocal Sobolev spaces (of zero order) in Orlicz spaces and demonstrates the existence of a least-energy weak solution of the Brezis-Nirenberg type, logistic type problem and eigenvalue problem involving the logarithmic Laplacian. For the uniqueness of the solution, we present a new Diaz-Saa type inequality, which is of independent interest and can be applied to a larger class of problems.

**Brezis-Nirenberg problems for mixed local-nonlocal operators with superlinear perturbations:
compactness and applications**

Schedule: July 8 15:00-15:30 Room 739

Mousomi Bhakta

Indian Institute of Science Education and Research Pune (IISER Pune), India

Abstract:

In this talk we will discuss a compactness result for the following class of subcritical/critical problems

$$-\Delta u + (-\Delta)^s u = \lambda |u|^{p-2} u + |u|^{p_n-2} u \text{ in } \Omega, \quad u = 0 \text{ in } \mathbb{R}^N \setminus \Omega,$$

where Ω is a bounded domain in $\mathbb{R}^N$, $N \geq 3$, $s \in (0, 1)$, $\lambda > 0$, $p_n \in (p, 2^*]$ and $p_n \rightarrow 2^* = \frac{2N}{N-2}$. Specifically for

$$p \in \left(2 + \frac{4s}{N-2}, 2^*\right), \text{ if } N > 6 - 4s; \quad (2^* - 1, 2^*), \text{ if } N \leq 6 - 4s,$$

we prove that if $\{u_n\}$ is any sequence of solution to the above equation with $\|u_n\|_{X_0} \leq C$ in some appropriate Sobolev space X_0 then u_n strongly converges in X_0 . To the best of our knowledge, this is the first paper to address this type of compactness result for a non-homogeneous operator. Due to the presence of the non-homogeneous operator, our proof requires a non-trivial adaptation of the methods developed by Devillanova and Solimini (Adv. Differential Equations, 2002) and Yan, Yang, and Yu (J. Funct. Anal., 2015). An application of this compactness result, under the same ranges of N and p , we establish infinitely many sign-changing solutions to the following Brezis-Nirenberg type problem:

$$-\Delta u + (-\Delta)^s u = \lambda |u|^{p-2} u + |u|^{2^*-2} u \text{ in } \Omega, \quad u = 0 \text{ in } \mathbb{R}^N \setminus \Omega.$$

On the homogenization of a class of variable exponent problems

Schedule: July 7 18:00-18:30 Room 739

Maria-Magdalena Boureanu

University of Craiova, Romania

Co-Author(s): Renata Bunoiu, Claudia Timofte

Abstract:

We study periodic strongly oscillating variable exponent problems driven by Leray-Lions type operators. We first prove that the problem under consideration admits a unique weak solution and establish a priori estimates. Then, using an appropriate convergence framework, we derive the homogenization result. This talk is based on a joint work with Renata Bunoiu and Claudia Timofte, carried out within Project 27 of the IRN ECO-Math program, Mathematics with Eastern and Central Europe (IMAR, Romania -- CNRS, France).

Weighted Isoperimetric Inequalities for Manifolds with Double Densities and Applications to PDEs

Schedule: July 8 9:30-10:00 Room 739

Francesco Chiacchio

Universita' degli Studi di Napoli Federico II, Italy

Co-Author(s): A. Alvino, F. Brock, A. Mercaldo, C. Nitsch, M. R. Posteraro, and C. Trombetti.

Abstract:

We investigate a class of isoperimetric inequalities in $\mathbb{R}^N$ characterized by the presence of two different positive weight functions in the volume and surface measures. A central role is played by radial power weights, $|x|^a$, for which we have solved the isoperimetric problem in many cases. We will present several applications, including Talenti-type estimates for elliptic equations and eigenvalue bounds for Steklov-type problems.

Fourth-order problems on extension domains involving variable exponents

Schedule: July 8 9:00-9:30 Room 739

Antonia Chinni

University of Messina, Italy

Co-Author(s): M.M.Boureau and B.Di Bella

Abstract:

We present a study on the existence of infinitely many weak solutions for a class of fourth-order elliptic problems involving variable exponents and Navier boundary conditions. The research is characterized by its broad approach, applying the analysis to $W^{2,p(\cdot)}$ -extension domains. This category encompasses not only smooth (Lipschitz) domains but also geometrically complex and non-smooth structures, such as fractals (e.g., the Koch snowflake). The problem is driven by nonhomogeneous Leray--Lions type operators, a choice that allows for the simultaneous treatment of several classical operators, including generalized Laplace, mean curvature, and capillarity operators, as well as $p(\cdot)$ -biharmonic operators. Furthermore, the study introduces new non-standard operators involving logarithmic and exponential functions. Methodologically, the main result is obtained by applying a variational principle for identifying infinitely many critical points. This approach overcomes the limitations of previous literature in two fundamental ways: absence of the Ambrosetti--Rabinowitz condition and absence of symmetry conditions: The existence of infinitely many solutions is guaranteed without imposing parity or symmetry on the nonlinearity. Instead, the nonlinear term only needs to exhibit suitable oscillatory behavior either at infinity or at zero.

Existence of solutions for a parametric weighted degenerate $p(\cdot)$ -Laplacian Dirichlet problem

Schedule: July 8 15:30-16:00 Room 739

Beatrice Di Bella

University of Messina, Italy

Abstract:

Fractional Dirichlet problems with singular and non-locally convective reaction

Schedule: July 8 8:30-9:00 Room 739

Laura Gambera

University of Catania, Italy

Co-Author(s): Salvatore Angelo Marano

Abstract:

In this communication, concerning a work with S. A. Marano, we investigate the existence of positive weak solutions for a Dirichlet problem driven by the fractional (p, q) -Laplacian operator. The problem is characterized by a reaction term that combines a weak singularity with a non-local convection dependence, specifically involving the distributional Riesz gradient of the solutions. Due to the presence of the convective term, the problem does not possess a direct variational structure. To address this difficulty, we combine sub-supersolution methods with variational techniques and truncation arguments. Furthermore, fixed-point results are employed to handle the non-local gradient term. Our main result establishes the existence of at least one positive weak solution, extending literature on fractional (p, q) equations to cases involving both singular and non-local gradient terms.

Multiple positive solutions for quasilinear nonlocal problem via topological, variational and set-valued methods

Schedule: July 7 18:30-19:00 Room 739

Leszek Gasinski

University of the National Education Commission, Poland

Abstract:

We study a nonlocal quasilinear problem driven by the p -Laplacian operator of a nonvariational type, without assuming any kind of monotonicity on the data. The nonlocal term depends on the L^q -norm of the unknown function, where p and q are independent exponents and the weight function can be sign changing. The multiplicity of positive solutions is established through a combination of variational methods, truncation techniques, set-valued analysis, and fixed-point results.

Existence and regularity results for nonlinear fractional order equations

Schedule: July 7 16:30-17:00 Room 739

Antonio Iannizzotto

University of Cagliari, Italy

Co-Author(s): Sunra Mosconi

Abstract:

We present some new results dealing with regularity, existence, and multiplicity of weak solutions for elliptic boundary value problems driven by the fractional p -Laplacian, and involving several types of reactions both bounded and unbounded. Special emphasis will be placed on boundary Hölder regularity, and the ways it affects comparison principles, existence of minimizers, a priori bounds, and multiplicity of solutions as an outcome.

Existence and multiplicity results for differential boundary value problems with possible discontinuous reaction

Schedule: July 8 17:00-17:30 Room 739

Roberto Livrea

University of Messina, Italy

Abstract:

The aim of the talk is to show some recent results regarding differential problems involving different boundary conditions. In particular, the critical point theory for non-differentiable functions is exploited for studying certain classes of parametric problems. Under suitable assumptions on the reaction terms, the existence of multiple solutions is established provided that the parameter belongs to different computable intervals. References 1. G. Bonanno and S. A. Marano, On the structure of the critical set of non-differentiable functions with a weak compactness condition, Appl. Anal., 89 (2010), 1-10 2. P. Candito, R. Livrea and B. Vassallo, Sturm-Liouville equations with discontinuous nonlinearity, preprint 3. R. Livrea, B. Vassallo. Three weak solutions to a periodic boundary Sturm-Liouville problem with discontinuous reaction, Discret. Contin. Dyn. Syst.-Ser. S, 2025, 18(6), 1660-1672. doi: 10.3934/dcdss.2024192

Solutions to critical equations with a superposition of nonlocal Hartree-type nonlinearities

Schedule: July 8 8:00-8:30 Room 739

Artur Marinho

Florida Institute of Technology, Brazil

Abstract:

We study a class of nonlinear nonlocal elliptic equations in R^N involving a superposition of Hartree-type nonlinearities. These equations are motivated by the Schrödinger--Poisson--Slater system and arise as natural generalizations of problems with a single nonlocal interaction term. We consider an equation driven by a family of Riesz potentials weighted by a positive Borel measure, leading to a superposed nonlocal operator. To treat this problem, we introduce suitable functional settings, namely the superposed Coulomb space and the associated superposed Coulomb--Sobolev space, and investigate their properties. Using variational methods combined with a recently developed scaling-based critical point theory, we establish existence and multiplicity results for radial solutions for a Brezis--Nirenberg type problem and show that multiplicity depends on the spectral properties of an associated nonlinear eigenvalue problem. Our results extend previous works on single Hartree-type equations and provide a unified framework to handle superpositions of nonlocal interactions of this type.

On elliptic problems involving local-nonlocal operator under mixed boundary conditions

Schedule: July 7 17:00-17:30 Room 739

Tuhina Mukherjee

Indian Institute of Technology Jodhpur, India

Co-Author(s): Dr. Lovelesh Sharma, Prof. Jacques Giacomoni

Abstract:

This talk shall be about a class of elliptic PDEs involving the mixed operator

$$\mathcal{L} = -\Delta + (-\Delta)^s, \text{ for } s \in (0, 1)$$

which are prescribed with mixed(Dirichlet-Neumann) boundary conditions. I shall discuss the corresponding eigenvalue problems and bifurcation type result(both from zero and infinity) for an asymptotically linear problem inclined with eigenvalue problems. Firstly, I will provide a functional setup that embeds a variational structure to problems with mixed operator and mixed boundary conditions. Under this framework, our first main result was the existence of the first eigenvalue and corresponding positive eigenfunctions with their expected characteristics viz. principal eigenvalue, simple and strictly positive. We also establish boundedness and Hölder regularity of eigenfunctions. We also show a strong maximum principle and a few other regularity results which are independent of interest. Secondly, I will show some asymptotic behavior of the first eigenvalues with respect to the Dirichlet set, when Neumann sets dissipate and vice versa. Lastly, I will discuss bifurcation type results, built upon the strong maximum principle and Hölder regularity results, for an asymptotically linear problem inclined with the eigenvalue problems.

Variational analysis of elliptic hemivariational inequalities with nonmonotone boundary conditions

Schedule: July 8 14:30-15:00 Room 739

Anna Ochal

Jagiellonian University in Krakow, Poland

Abstract:

We investigate a class of nonlinear elliptic boundary value problems formulated as hemivariational inequalities. These problems arise naturally in the study of steady-state heat conduction where the boundary conditions are nonmonotone and multi-valued. Such conditions are described by the Clarke generalized gradient of a locally Lipschitz continuous function on a portion of the boundary. Applying variational methods, we establish the existence of solutions for this class of inequalities [1]. In this talk, we discuss the system's sensitivity to parameters such as the heat transfer coefficient. We present results concerning the existence of optimal solutions for related control problems and provide an asymptotic analysis showing the behavior of the system states as the parameter tends to infinity. This contribution aligns with new trends in nonlinear boundary value problems by showcasing the application of subdifferential analysis to local differential operators with complex boundary interactions. [1] C.M. Gariboldi, S. Migorski, A. Ochal, and D.A. Tarzia, Existence, comparison, and convergence results for a class of elliptic hemivariational inequalities, Appl. Math. Optim., 84 (Suppl 2) (2021), S1453--S1475.

Convergence Analysis of a Differential Variational Inequality

Schedule: July 8 13:30-14:00 Room 739

Mircea Sofonea

University of Perpignan, France

Co-Author(s): Mircea Sofonea and Bruno Vassallo

Abstract:

We deal with the study of a special class of systems which couple an implicit differential equation with an evolutionary variational inequality. Following the terminology used in the literature, we refer to such systems as differential variational inequalities (DVI). Inequalities of this form arise in a large number of mathematical models in Solid and Contact Mechanics. We start with a one dimensional rheological example which leads to a DVI. Inspired by this example, we formulate the problem in the abstract framework of a real Hilbert space, then we state and prove an existence and uniqueness result. The proof is based on a result of evolutionary variational inequalities combined with a fixed point argument for history-dependent operators. We proceed with a convergence criterion, that is, we identify necessary and sufficient condition which guarantee the convergence of an arbitrary sequence to the solution. We introduce a well-posedness concept for the DVI we study, then and prove the corresponding well-posedness result. Finally, we apply these abstract results in the study of the one-dimensional rheological model and provide the corresponding mechanical interpretations.

The superposition of operators of mixed fractional order and their applications

Schedule: July 8 16:30-17:00 Room 739

Caterina Sportelli

Universidad de Granada, Spain

Abstract:

In this talk we introduce the superposition operator $\int_{[0,1]} (-\Delta)^s u d\mu(s)$, where μ denotes a (Borel) signed measure on the fractional interval $[0, 1]$. We discuss the existence of solutions for some problems in presence of the operator (???) and subject to different types of boundary conditions. These results are part of some joint works with Serena Dipierro, Enrico Valdinoci and Kanishka Perera.

Morse-theoretic approach for logarithmic double phase problems

Schedule: July 7 17:30-18:00 Room 739

Patrick Winkert

University of Technology Berlin, Germany

Abstract:

In this talk, we investigate nonlinear elliptic problems involving logarithmic double phase operators and superlinear nonlinearities. Using critical group theory and variational methods, we show that the problem admits at least three distinct nontrivial bounded weak solutions. Two of these solutions have constant sign and positive energy, while a third is obtained via a topological argument involving the structure of the critical groups at zero and at infinity. This talk is based on joint works with Franziska Borer (Berlin), Vicen\c{t}iu D. R\{u}dulescu (Krakow) and Matheus F. Stapenhorst (Presidente Prudente).

Special Session 94 : Dynamics and Variational Methods of Quasi-Hamiltonian Systems

Organizer(s): Xifeng Su , Jianlu Zhang

Introduction: We will communicate with the researches on Dynamical Systems and related topics, including Hamiltonian Dynamics and models of quasi-crystals etc. Everyone in the workshop could take the chance to know each other and to collaborate with each other in the future. The topics Includes but are not limited to 1, generic hyperbolicity of Aubry sets, Mane conjecture and related rigidity problems (such as Hopf type results); 2, existence and stability of weak KAM solutions and their connection with the ones of the corresponding partial differential equations/systems; 3, the non-local version of Moser-Bangert theory; 4, more related topics.

Invariant Tori in Hamiltonian and Conformally Symplectic Systems: A Posteriori KAM Theory and Computation

Schedule: July 7 13:30-14:00 Room 312

Renato C Calleja

IIMAS-UNAM, Mexico

Co-Author(s): Pedro Porras, Alex Haro, Arturo Vieiro

Abstract:

This talk presents recent and ongoing work on invariant tori in Hamiltonian systems with quasi-periodic time dependence and in conformally symplectic systems. In joint work with Pedro Porras and Alex Haro, we developed an a posteriori KAM theorem for Lagrangian invariant tori in Hamiltonian flows with quasi-periodic forcing. The proof is based on the parameterization method and a Newton-like scheme using adapted symplectic frames and an intrinsic torsion matrix, leading to efficient quadratically convergent algorithms under standard Diophantine and nondegeneracy conditions. I will also discuss current work with Alex Haro and Arturo Vieiro on secondary tori near elliptic points and on resonance capture in near-symplectic dynamics via Birkhoff normal forms. These problems illustrate how the same functional analytic and geometric ideas extend from conservative to weakly dissipative settings. The parameterization method provides a common framework throughout, connecting rigorous existence theory, effective numerical computation, and the study of breakdown and bifurcation phenomena for quasi-periodic invariant objects.

On selection problems for second-order Hamilton-Jacobi equations

Schedule: July 7 17:00-17:30 Room 312

Qinbo Chen

Nanjing University, Peoples Rep of China

Abstract:

This talk concerns the simultaneous effects of the discounted approximation and the potential perturbation in second-order degenerate elliptic Hamilton-Jacobi equations. Our analysis relies on generalized (stochastic) Mather measures selected via the nonlinear adjoint method, which enables us to derive a new selection mechanism for second-order Hamilton-Jacobi equations.

Long time stability of Hamiltonian derivative nonlinear Schrödinger equations

Schedule: July 7 16:30-17:00 Room 312

Shengqing Hu

Shenzhen SMU-BIT University, Peoples Rep of China

Abstract:

In this talk, we study an abstract Birkhoff normal form theorem for some unbounded infinite dimensional Hamiltonian systems. Based on this result, we obtain that the solution to derivative nonlinear Schrödinger equations with typical small enough initial value remains small in Sobolev norm over a subexponential long time interval.

Cartan-Schouten Connections: Geometric Reduction and a Connection-Dependent Variational Principle

Schedule: July 7 14:00-14:30 Room 312

Qiao Huang

Southeast University, Peoples Rep of China

Abstract:

We study the family of Cartan-Schouten connections on Lie groups, parameterized by $\lambda \in [0, 1]$, whose geodesics through the identity are one-parameter subgroups. We compute their curvature, torsion, parallel transport, and geodesics, and develop Euler-Poincaré and Lie-Poisson reduction for mechanical systems via these connections, unifying the "minus" and "plus" cases. These inspire us to introduce a connection-dependent variational principle where the Lagrangian is expressed in terms of the parallel-transported velocity, leading to an integro-differential Euler-Lagrange equation that explicitly involves torsion and curvature memory terms.

Comparison principle of general Hamilton-Jacobi equations and applications

Schedule: July 7 18:00-18:30 Room 312

Gengyu Liu

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Zhang Jianlu, Tu Son

Abstract:

In this talk, we investigate contact Hamilton-Jacobi equations $H(x, du, u) = c$ and $H(x, du, u) = c + \Delta u$ under the condition that the contact direction is not strictly positive definite. Correspondingly, we describe the structure of $\mathfrak{C}$ containing all the $c \in \mathbb{R}$ that makes the equations solvable and establish general comparison principles. As applications, we employ these comparison principles to obtain quantitative homogenization results.

Mean Field Games of Controls with Boundary Conditions & Invariance Constraints

Schedule: July 7 15:00-15:30 Room 312

Kyle Rosengartner

Baylor University, USA

Co-Author(s): Jameson Graber

Abstract:

In a mean field game of controls, a large population of identical players seek to minimize a cost that depends on the joint distribution of the states of the players and their controls. We first consider the classes of mean field games of controls in which the value function and the distribution of player states satisfy either Dirichlet or Neumann boundary conditions. We prove that such systems are well-posed either with sufficient smallness conditions or in the case of monotone couplings. Next, we consider mean field games of controls under invariance constraints imposed on the state space. We prove the existence and uniqueness of weak solutions to our mean field game system, and then we prove higher regularity of solutions under some additional assumptions.

On the vanishing viscosity limit of Hamilton-Jacobi equations

Schedule: July 7 14:30-15:00 Room 312

Zibo Wang

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

In this talk, we try to develop a unified framework for the vanishing viscosity limit of Hamilton-Jacobi equations. Our approach aims to establish the convergence of viscous approximations within the class of Tonelli Hamiltonians. Moreover, we provide quantitative estimates on the rate of convergence. This is a joint work with Jianlu Zhang.

Uniqueness results of ground states for mixed Laplacian and fractional Laplacian.

Schedule: July 7 15:30-16:00 Room 312

Jiwen Zhang

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

In this talk, I will report some recent uniqueness results for the radial solutions to linear and nonlinear Schrödinger equations involving mixed Laplacian and fractional Laplacian. We prove that the linear equation admits at most one bounded radial solution, provided that the potential is radial, nondecreasing and Hölder continuous. Moreover, the nonlinear Schrödinger equation possesses a unique ground state solution and is nondegenerate when s is close to 0 or 1.

Periodic, Quasi-Periodic and Almost Periodic Solutions of the Hamilton-Jacobi Equation

Schedule: July 7 17:30-18:00 Room 312

Kai Zhao

Tongji university, Peoples Rep of China

Co-Author(s): Kai Zhao

Abstract:

It is well known that there exist no non-trivial periodic solutions for classical Hamilton-Jacobi equations. Combining the weak KAM method for contact Hamiltonian systems with the viscosity solution theory of the Hamilton-Jacobi equation, we have recently investigated the problem of time periodic solutions for contact Hamilton-Jacobi equations. Under certain conditions, quasi-periodic solutions and almost periodic solutions can also emerge. Furthermore, we have explored the chaotic nature of the large time behavior of the solutions.

Special Session 95 : The Euler Water Wave Problem

Organizer(s): Bernard Deconinck , Dmitry Pelinovsky , Anastasiya Semenova

Introduction: Recent activity has resulted in spectacular breakthroughs on the mathematical understanding of the dynamics and stability of surface water waves in different regimes. In this session, advances on the study of the Euler equations describing surface water waves will be presented, using analytical and computational approaches.

Rational approximation and branch cuts for standing water waves

Schedule: July 7 9:30-10:00 Room 823

Jon A Wilkening

UC Berkeley, USA

Co-Author(s): Ahmad Abassi

Abstract:

We compute arbitrary-order asymptotic expansions of standing water waves, generalizing the conformal mapping framework of Schwartz and Whitney (1981) to handle finite-depth domains and/or surface tension effects. The calculations are performed in arbitrary precision with up to 3000 bits using MPFR and parallelized to run on a supercomputer. We explore Padé approximations of the expansions and observe branch cuts that leave gaps in the families of solutions. We also explore analytic continuation of standing waves into the upper half-plane and observe branch cuts there as well.

Recovery of finite-genus KP solutions from data

Schedule: July 6 17:30-18:00 Room 823

Levent Batakci

University of Washington, USA

Abstract:

The Kadomtsev-Petviashvili (KP) equation describes 3-dimensional waves in shallow water with weak dependence on the second spatial variable. Solutions of the KP equation with finitely many interacting phases can be expressed in terms of the Riemann theta function, and complex algebraic curves can be used to determine the parameters (e.g. wave vectors) therein. Particularly, a KP solution corresponding to a curve on a genus- g surface will have g phases present. We develop a new framework for the recovery problem: given a KP solution as a set of data values, we determine the corresponding genus and parameters. Our framework is rooted in Fourier analysis alongside a non-linear optimization step, which we recast as two linear least-squares problems. Whereas previous works were limited to recovery of genus 2 solutions, our framework is applicable to higher genus.

Amplification of interacting solitons in Kadomtsev-Petviashvili and bi-directional water-wave equations

Schedule: July 6 17:00-17:30 Room 823

Onno Bokhove

University of Leeds, England

Co-Author(s): Onno Bokhove and Shoaib Mohammed

Abstract:

Extreme water-wave motion is investigated by considering soliton interactions on a horizontal plane. We determine numerically that soliton solutions of the unidirectional Kadomtsev-Petviashvili equation (KPE), with equal far-field individual amplitudes, survive well in the bidirectional and higher-order Benney-Luke and potential-flow equations (BLE and PFE). An exact two-soliton solution of the KPE on the infinite horizontal plane is used to seed BLE and PFE at an initial time, verifying that the KPE-fourfold amplification approximately persists. More extremely, a known three-soliton solution of the KPE is analysed, in a combined geometric-analytical approach proving its ninefold amplification. This three-soliton solution leads to an extreme splash at one location in space and time. Subsequently, we seed BLE and PFE with that three-soliton solution at a suitable initial time prior to and establish its maximum numerical amplification: it is at least 7.6 to 9 for an exact KPE amplification of 9 (depending on the choice of small parameters). In our simulations, computational domain and solutions are truncated approximately to a fully periodic or half-periodic channel geometry of sufficient size, essentially leading to ("time-periodic") cnoidal-wave solutions. Special geometric (finite-element) variational integrators in space and time have been used to avoid artificial numerical damping of wave amplitude. A larger goal, in progress, is to use these simulations for designs of suitable wave-tank experiments. Finally, we investigate whether an analytical solution of the KPE with four line-solitons of far-field amplitude A can yield amplitude $16A$ at the origin in space-time.

Spectral Stability of High Amplitude Waves

Schedule: July 6 14:30-15:00 Room 823

Eleanor D Byrnes

University of Washington, USA

Abstract:

The spectral stability of the Euler water wave problem has been well studied both numerically and analytically for low amplitude waves. High amplitude waves in infinite depth have also been thoroughly studied numerically, with asymptotic results regarding a number of critical eigenvalue bifurcations emerging recently. I will present numerical and asymptotic work on the stability of high amplitude waves in finite depth

Stability of Near-Extreme Solutions of the Whitham Equation

Schedule: July 6 18:00-18:30 Room 823

John Carter

Seattle University, USA

Abstract:

The Whitham equation is a model for the evolution of small-amplitude, unidirectional waves of all wavelengths on shallow water. It has been shown to accurately model the evolution of waves in laboratory experiments. We compute 2π -periodic traveling-wave solutions of the Whitham equation and numerically study their stability with a focus on solutions with large steepness. We show that the Hamiltonian oscillates as a function of wave steepness when the solutions are sufficiently steep. We show that a superharmonic instability is created at each extremum of the Hamiltonian and that between each extremum the stability spectra undergo similar bifurcations. Finally, we compare these results with those from the Euler equations.

The Stokes waves on ideal fluid: modulational instability and wave breaking

Schedule: July 6 15:00-15:30 Room 823

Sergey Dyachenko

State University of New York at Buffalo, USA

Co-Author(s): Bernard Deconinck, Elleanor Byrnes, Anastassiya Semenova, Pavel Lushnikov

Abstract:

The long-standing problem of stability of surface waves on 2D fluid is solved in conformal variables for Stokes up to nearly extreme steepness. The stability spectrum of Stokes waves exhibits recurrent transitions, multiple modulation, or Benjamin-Feir instability branches. We show that all Stokes waves are, in fact, unstable, but the nature of these instabilities varies -- in some cases it leads directly to wave-breaking, and, in others, to modulational disturbance and appearance of rogue waves in the ocean swell. We discuss the profound change in the numerical approach that allowed us to consider nearly extreme Stokes waves.

Wave resonances in a water world

Schedule: July 6 16:30-17:00 Room 823

Paul Milewski

Penn State, USA

Co-Author(s): Matt Durey, Emilian Parau

Abstract:

Nonlinear resonance is a mechanism by which energy is continuously exchanged between a small number of wave modes and is common to many nonlinear dispersive wave systems. In the context of free-surface gravity waves such as ocean surface waves, nonlinear resonances have been studied extensively over the past 60-years, almost always on domains that are large (or infinite) compared to the characteristic wavelength. In this case, the dispersion relation dictates that only quartic (4-wave) resonances can occur. In contrast, nonlinear resonances in compact three-dimensional geometries have received relatively little attention, where, perhaps surprisingly, stronger gravity 3-wave resonances can occur. We will present the results characterizing the configuration and dynamics of resonant triads in cylindrical basins of arbitrary cross sections, demonstrating that these triads are ubiquitous, with (the commonly studied) rectangular cross section being an exception where they do not occur. We then consider planetary scale resonances on a sphere, again showing that 3-wave resonances are possible.

Transverse Instability of Small-Amplitude Finite-Depth Stokes Waves

Schedule: July 6 13:30-14:00 Room 823

Luis Miguel Rodrigues

Univ Rennes, France

Co-Author(s): Ziang Jiao, Zhao Yang (Beijing, China), Changzhen Sun (Besançon, France)

Abstract:

We report on a recent proof that all irrotational planar periodic traveling waves of sufficiently small-amplitude are spectrally unstable as solutions to three-dimensional inviscid finite-depth gravity water-waves equations. The associated temporal growth scales sharply with respect to the amplitude of the wave.

Two-Crested Stokes Waves

Schedule: July 7 9:00-9:30 Room 823

Anastassiya Semenova

Rochester Institute of Technology, USA

Abstract:

The study of surface gravity waves is crucial for understanding the formation of rogue waves and whitecaps in ocean swell. Waves originating from the epicenter of a storm can often be approximated as unidirectional. In this presentation, we explore periodic traveling waves on the free surface of an ideal two-dimensional fluid. We focus on surface waves of permanent shape, and present new families of Stokes waves and discuss their stability.

Well-posedness of vortex sheets in 3D flow with unequal density fluids

Schedule: July 7 8:00-8:30 Room 823

Michael Siegel

New Jersey Institute of Technology, USA

Abstract:

We prove local well-posedness for a 2D vortex sheet separating two fluids of different densities in a 3D flow. The sheet evolves in a potential flow under the combined effects of gravity and surface tension. Our approach follows the method of Ambrose and Masmoudi, who treated the density-matched case. The main challenge in the unequal-density setting is a more complicated equation governing the vortex sheet strength, which is determined by the jump in velocity potential across the interface. The velocity potential can be represented as a boundary integral of dipoles. In the density-matched case, the dipole strength μ satisfies an explicit time-evolution equation. In contrast, when the densities differ, μ_t appears implicitly in a singular integral equation, which must first be inverted to find the evolution equation for μ . The regularity of the vortex-sheet strength is established by combining new estimates with a bootstrap argument. This is joint work with Joseph Cavatchel (NJIT) and David Ambrose (Drexel).

Instability Mechanisms in 2D Fluids

Schedule: July 7 8:30-9:00 Room 823

Paolo Ventura

EPFL, Switzerland

Co-Author(s): Gonzalo Cao-Labora, Maria Colombo, Michele Dolce, Luca Franzoi, Riccardo Montalto

Abstract:

In this talk I will discuss some instability results for two-dimensional fluid equations. I will first present results on the long-wave instability of periodic shear flows for the 2D Navier--Stokes equations (joint work with M. Colombo, M. Dolce, and R. Montalto), as well as results on the instability of a family of equilibria for the two-dimensional Euler equations (joint work with G. Cao Labora, M. Colombo, and M. Dolce). I will also describe work in progress with A. Franzoi and R. Montalto on the existence of infinitely many unstable eigenvalues for the 2D Euler equations linearized around a traveling wave.

Stability and instability of gravity-capillary waves

Schedule: July 6 14:00-14:30 Room 823

Erik Wahlén

Lund University, Sweden

Co-Author(s): Mariana Haragus, Wei Lian, Changzhen Sun, Tien Truong

Abstract:

I will report on recent progress on the spectral stability and instability of periodic travelling gravity-capillary waves for the irrotational water wave problem in two space dimensions (one-dimensional surface). This includes both co-periodic, transverse and localised perturbations. I will also discuss some implications for the stability of generalised solitary waves, consisting of a localised hump with periodic ripples in the far field.

Special Session 96 : Recent Trends in Navier-Stokes Equations, Euler Equations, and Related Problems

Organizer(s): Sarka Necasova , Reimund Rautmann , Werner Varnhorn

Introduction: For many decades, the basic equations of fluid dynamics have been the focus of great interest and active research worldwide. Recently developed approaches and analytical tools helped to establish new criteria of uniqueness, stability, and regularity of weak and mild solutions, depending on different conditions of the data, and results concerning multi-component flows. The same applies to the reaction between fluids and immersed bodies, such as boundary control of self-propelled objects. Moreover, we dispose of new results concerning the asymptotic behaviour of suitable unsteady weak solutions with increasing time or with vanishing viscosity, and also concerning the general question whether or not the unsteady Navier-Stokes equations admit global attractors. Therefore, our Special Session aims at bringing together researchers from all over the world working in all of these or related fields in order to initiate fruitful discussions and cooperation.

L^p

-theory for the operator

$\operatorname{curl}(\alpha \operatorname{curl} \dot{})$

and applications

Schedule: July 8 16:30-17:00 Room 428

Cherif Amrouche

Universite de Pau et des Pays de l'Adour, France

Co-Author(s): Lisa Santo

Abstract:

In this work, we develop an L^p -theory for the existence of weak and strong solutions to the elliptic problem

$$-\operatorname{div}(a \nabla u) = f,$$

in a bounded open domain of $\mathbb{R}^N$, under Dirichlet or Neumann boundary conditions, and under suitable assumptions on the data and on the regularity of the domain boundary. We also develop an L^p -theory for the existence of weak and strong solutions to the vector-valued problem defined in a bounded open multiply connectde domain of $\mathbb{R}^3$,

$$\operatorname{curl}(\alpha \operatorname{curl} h) = f,$$

considering both perfectly permeable and perfectly conducting boundary conditions, and different assumptions on f and on the regularity of $\partial\Omega$. As an application, we study a coupled electromagnetic induction heating problem, obtaining improved regularity results for the solutions compared to those available in the existing literature.

Inviscid incompressible limit of the compressible Navier-Stokes system with a moving rigid body

Schedule: July 7 18:00-18:30 Room 428

Kuntal Bhandari

Institute of Mathematics of the Czech Academy of Sciences, Czech Rep

Co-Author(s): $\{S\}^{\{a\}} \text{rka Ne}\{c\} \text{asov}\{a\}$, Arnab Roy

Abstract:

We present the inviscid incompressible limit of a system of compressible Navier-Stokes equations interacting with a moving rigid body. Both cases of no-slip and Navier-slip condition on the fluid-rigid body interface will be considered.

On the stability of steady states for a generalized Navier-Stokes-Fourier system

Schedule: July 8 13:30-14:00 Room 428

Petr Kaplický

Charles University, Czech Rep

Co-Author(s): Karol Hajduk, Aneta Wroblewska

Abstract:

We consider the flow of a generalized non-Newtonian incompressible heat-conducting fluid in a bounded domain $\Omega \subset \mathbb{R}^3$, subject to Dirichlet boundary conditions for both velocity and temperature. While we assume homogeneous Dirichlet boundary conditions for the velocity, which prohibit the exchange of mass with the surroundings, we allow nonhomogeneous Dirichlet boundary conditions for the temperature, which enforces heat exchange with the surroundings. The fluid obeys a power-law constitutive relation for the Cauchy stress, and the thermal conductivity is assumed to be a nonlinear function of the temperature, which may degenerate or become unbounded. No external forces are considered. We study the long-time behaviour of the system. We show that the steady state of the system is nonlinearly stable within a suitably defined class of solutions. We also prove the existence of such solutions. This is follow-up research to the work done together with A. Abbatiello and M. Bulíček. It is joint work with Aneta Wroblewska and Karol Hajduk.

Time-periodic solutions to incompressible flows in moving domains

Schedule: July 7 17:00-17:30 Room 428

Ondrej Kreml

Institute of Mathematics, Czech Academy of Sciences, Czech Rep

Abstract:

We study the flow of an incompressible viscous fluid in a domain which changes shape periodically in time. We show that this problem admits a time-periodic weak solution. We are able to remove all smallness assumptions which were imposed in the previous results.

On time-periodic solutions to an interaction problem between compressible viscous fluids and viscoelastic beams

Schedule: July 7 17:30-18:00 Room 428

Vaclav Macha

Institute of Mathematics, Czech Academy of Sciences, Czech Rep

Abstract:

We study a nonlinear fluid-structure interaction problem between a viscoelastic beam and a compressible viscous fluid. The beam is immersed in the fluid which fills a two-dimensional rectangular domain with periodic boundary conditions. Under the effect of periodic forces acting on the beam and the fluid, at least one time-periodic weak solution is constructed which has a bounded energy and a fixed prescribed mass.

Dynamic interaction between a rigid-body and an incompressible viscous fluid: some new results for the IBVP

Schedule: July 7 16:30-17:00 Room 428

Paolo Maremonti

Università degli Studi della Campania "L. Vanvitelli", Italy

Abstract:

We investigate some analytic questions concerning the solutions to the equations of a model related to the dynamical interaction between a rigid-body and a viscous incompressible fluid. The model is a generalization of Oseen problem related to the ordinary Navier-Stokes equations. Actually, on its surface ∂B , the rigid body B is forced by the Newtonian stress tensor, that is the dynamical answer of the incompressible fluid. We are able to discuss some questions of uniqueness of regular solutions, asymptotic properties of the solutions and a possible structure theorem related to a suitable weak solution. All the questions are studied by considering the IBVP in a frame which is attached to the rigid body. This frame from one side simplifies the approach to the existence of solutions, from another side it makes the inconvenient to introduce the velocity of the rigid motion inside the equations as a coefficient. In its entirety the problem of the existence of regular solutions was solved in 2002, the case of global solutions for small data in 2023, instead the other questions, that are the uniqueness, asymptotic behavior of the kinetic energy and partial regularity of a weak solution, they were open problems until 2025.

Thermal effects in fluid structure interactions

Schedule: July 8 8:30-9:00 Room 428

Sourav Mitra

IIT Indore, India

Abstract:

In this talk we consider two different heat conducting fluids each modeled by the incompressible Navier-Stokes-Fourier system separated by a non-linear elastic Koiter shell. The motion of the shell changes the domain of definition of the two separated fluids. For this setting we show the existence of a weak solution. We follow a variational approach for fluid-structure interactions. To include temperature a novel two step minimization scheme is used to produce an approximation. The weak solutions are energetically closed and include a strictly positive temperature.

Regular Solutions in Fluid Mechanics: Choosing Between Besov and Sobolev Frameworks

Schedule: July 8 14:30-15:00 Room 428

Piotr B Mucha

University of Warsaw, Poland

Abstract:

The analysis of regular solutions to fluid mechanics equations typically begins with a concession: we assume smallness conditions on the initial data. This is not a choice of convenience, but a mathematical necessity that allows us to treat the system as a perturbation of a linear problem. Once this regime is established, the central technical challenge becomes the selection of an appropriate functional framework. This talk examines the practical trade-offs between Besov and Sobolev spaces when constructing these solutions. While Besov spaces offer refined tools for frequency localization and critical scaling -- often providing better results in the whole space R^n -- they frequently become a liability when dealing with physical boundaries. Conversely, Sobolev spaces, while perhaps less sharp in a scaling sense, provide a more robust environment for handling boundary conditions and integration by parts. Through specific examples in both unbounded and bounded domains, I will discuss the advantages and disadvantages of each approach. The goal is to illustrate that the best space is rarely universal, but rather depends on whether one prioritizes frequency-side precision or physical-space boundary compatibility.

The primitive equations and conjecture of Onsager

Schedule: July 8 17:30-18:00 Room 428

Sarka Necasova

Czech Academy of Sciences, Czech Rep

Co-Author(s): M.A. Rodriqez-Bellido, T. Tang, , E. Wiedeman, L. Zhu

Abstract:

In the talk, we will focus on the problem of the conservation of energy for the weak solutions to the compressible primitive equations system with degenerate viscosity. This part of the talk is based on collaboration with M.A. Bellido and T. Tang. Moreover, we will consider the Onsager conjecture for the incompressible primitive system in a bounded domain. This part of the talk is based on the collaborations with E. Wiedemann, T. Tang, and L. Zhu.

Long time density-dependent Navier-Stokes equations with large flux

Schedule: July 8 9:30-10:00 Room 428

Joanna Renc{\l}awowicz

Institute of Mathematics and Cryptology, Cybernetics Faculty, Military University of Technology, Poland

Co-Author(s): Wojciech Zaj{\c}czkowski

Abstract:

The nonhomogeneous (density-dependent) Navier-Stokes equations are considered in a cylindrical domain in R^3 , parallel to the x_3 -axis with large inflow and outflow on the top and the bottom. Moreover, on the lateral part of the cylinder the slip boundary conditions are assumed. The long-time existence of regular solutions is proved under assumptions that inflow and outflow are close to homogeneous and norms of derivatives with respect to x_3 of the external force and initial velocity are sufficiently small. The key point is to verify that the x_3 -coordinate of velocity remains positive.

Divergence-Free Dual Spaces and L^p Analysis for the Stokes and Navier--Stokes Equations with Mixed Navier-Type Boundary Conditions

Schedule: July 8 8:00-8:30 Room 428

Nour Seloula

University of Caen Normandie, France

Co-Author(s): Imane Boussetouan and Cherif Amrouche

Abstract:

In this talk, we study the stationary Stokes and Navier--Stokes equations in an L^p framework under mixed Navier-type boundary conditions, combining Dirichlet conditions on part of the boundary with prescribed normal trace and tangential vorticity on the complementary part. A central aspect of this work is the precise characterization of the dual spaces associated with divergence-free function spaces adapted to these boundary conditions. This duality framework allows for a rigorous variational formulation beyond the Hilbert setting. As an application, we establish the existence of weak and strong solutions in the L^p theory for both the Stokes and Navier--Stokes systems under these mixed boundary conditions.

On the Navier-Stokes equations with energy-stable outflow boundary conditions

Schedule: July 8 15:00-15:30 Room 428

Ana Silvestre

Instituto Superior T cnico, Universidade de Lisboa, Portugal

Abstract:

We are interested in flow of a viscous incompressible fluid in distorted pipes of finite length, modeled through the Navier-Stokes equations with mixed boundary conditions. At the outlets, directional do-nothing boundary conditions are imposed on the fluid motion. We investigate existence, uniqueness and regularity of solutions in the $2d$ and $3d$ cases. This is joint work with Alessio Falocchi (Politecnico di Milano, Italy) and Gianmarco Sperone (Pontificia Universidad Cat lica de Chile, Santiago).

Long-time behavior of solutions to fluid dynamic shape optimization problems via phase-field method

Schedule: July 8 9:00-9:30 Room 428

John Sebastian H Simon

University of Koblenz, Germany

Co-Author(s): Michael Hinze and Christian Kahle

Abstract:

We investigate the long time behavior of solutions to a shape and topology optimization problem with respect to the time-dependent Navier--Stokes equations. The sought topology is represented by a stationary phase-field that represents a smooth indicator function. The fluid equations are approximated by a porous media approach and are time-dependent. In the latter aspect, the considered problem formulation extends earlier work. We prove that if the time horizon tends to infinity, minima of the time-dependent problem converge towards minima of the corresponding stationary problem. To do so, a convergence rate with respect to the time horizon, of the values of the objective functional, is analytically derived. This allowed us to prove that the solution to the time-dependent problem converges to a phase-field, as the time horizon goes to infinity, which is proven to be a minimizer for the stationary problem. We validate our results by numerical investigation.

Some remarks on Leray's structure theorem

Schedule: July 8 17:00-17:30 Room 428

Werner Varnhorn

Institute of Mathematics, Kassel University, Germany

Abstract:

We consider a general weak solution of the nonstationary nonlinear Navier-Stokes equations and extend some results concerning Leray's structure theorem by omitting the strong energy inequality.

Coupled Vlasov and non-Newtonian dynamics

Schedule: July 8 14:00-14:30 Room 428

Aneta Wróblewska-Kamińska

Institute of Mathematics, Polish Academy of Sciences, Poland

Abstract:

We study a coupled kinetic-non-Newtonian fluid system on the periodic domain $\mathcal{T}^3$, where particles evolve by a Vlasov equation and interact with an incompressible power-law fluid through a drag force. We prove the global existence of weak solutions for all $p > \frac{8}{5}$, where $p > 1$ denotes the power-law exponent of the fluid's stress-strain relation. Under an additional uniform boundedness assumption on the particle density, we also establish large-time decay of a modulated energy functional measuring deviation from velocity alignment. The decay rate is algebraic when $p > 2$ and exponential when $\frac{6}{5} \leq p \leq 2$, reflecting the role of fluid dissipation in the large-time dynamics. This is recent joint work with Young-Pil Choi and Jinwook Jung.

Special Session 98 : Control, Inverse problems and Long time dynamics of Evolutionary Systems

Organizer(s): LOUIS TEBOU , Marcelo CAVALCANTI , Valeria DOMINGOS CAVALCANTI

Introduction: This special session focuses on the latest developments in control theory, inverse problems and long time behavior of evolution equations and systems, which are some of the most fundamental mathematical aspects for studying evolution systems. Evolution equations and systems are partial differential equations and systems that describe the time evolution of some natural phenomena. They arise from many areas of applied and engineering sciences. The rich methodologies developed in those areas may also be applied in much broader fields such as aerophysics, finance, medical imaging or biology,... This special session will bring together mathematicians from different backgrounds and stages of career to share their recent research findings on the proposed topics, and also provide a platform for professional networking and collaboration.

On the stability of a thermoelastic transmission problem with Kelvin-Voigt Damping

Schedule: July 8 14:30-15:00 Room 314

Maria Astudillo

Federal University of Parana, Brazil

Co-Author(s): Antonio Leite Guimaraes, Higidio Portillo Oquendo

Abstract:

In this talk, we consider a transmission problem for a string composed of three different types of materials: an elastic material (without dissipation), a thermoelastic material and a Kelvin-Voigt viscoelastic material. We discuss how the position of the different components plays an important role in the study of the stabilization. In particular, when considering three distinct components, as expected, when the viscoelastic component is not in the middle of the material, then there exists exponential stability of the solution. On the other hand, when the viscoelastic part is in the middle of the material, the exponential stability of the system achieved through the dissipation given by the heat conduction is destroyed by the local Kelvin-Voigt damping with a discontinuous coefficient at the interface. In this case, the solution decays polynomially as t^{-2} .

Implications of a Novel Pressure Elimination Method for a Certain Nonlinear Fluid-Structure PDE Interaction

Schedule: July 7 13:30-14:00 Room 314

George Avalos

University of Nebraska-Lincoln, USA

Co-Author(s): Yuhao Mu

Abstract:

In this talk we present some implications of our new technique for eliminating and recovering the pressure for a particular fluid-structure interaction model, a technique which is valid for general bounded Lipschitz domains. The specific fluid-structure interaction (FSI) that we consider is a well-known model of coupled Navier-Stokes flow with linear elasticity. The coupling between these two distinct PDE dynamics occurs across a boundary interface, with each of the components evolving on its own distinct geometry, and with the boundary interface being Lipschitz. Among other consequences, the new pressure elimination technique leads to a proof of well-posedness of the PDE system, globally in time in 2D (and 3D with small data assumptions), with again, this wellposedness being valid for general Lipschitz geometries.

Infinite Horizon Control Problems for Semilinear Parabolic Equations with Pointwise State Constraints

Schedule: July 8 8:30-9:00 Room 314

Lorena Bociu

NC State University, USA

Co-Author(s): Eduardo Casas

Abstract:

We consider an optimal control problem for semilinear parabolic equations with infinite horizon, pointwise state constraints and two different types of control constraints (pointwise in space and time, and pointwise in time and L^2 in space). We present new results on first-order necessary conditions and second-order sufficient condition for local optimality. We also address the approximation of the infinite horizon control problem by finite horizon problems. We analyze the convergence of these approximations and provide error estimates.

Stabilization of the Critical Wave Equation via Energy-Dependent Nonlinear Damping

Schedule: July 8 15:30-16:00 Room 314

Marcelo Cavalcanti

State University of Maringa, Brazil

Co-Author(s): Valeria N. Domingos Cavalcanti, Josiane C. O. Faria, Cintya A. Okawa

Abstract:

We investigate a semilinear wave equation with energy critical nonlinearity and a nonlinear damping mechanism driven by the total energy of the system. The model combines the quintic defocusing term with a time dependent dissipation of the form $E(t)u_t$, which introduces a nonstandard feedback structure coupling the dynamics and the energy functional. Weak solutions are constructed via Galerkin approximations, with the passage to the limit relying on uniform energy estimates and compactness arguments. Special attention is devoted to the critical nature of the nonlinearity, where concentration phenomena prevent purely energy-based methods from yielding refined spacetime control. This difficulty is resolved by incorporating nonhomogeneous Strichartz estimates together with smoothly truncated spectral approximations, ensuring uniform bounds at the dispersive level. Finally, we establish polynomial decay rates for the energy by adapting Nakao's method to the present nonlinear dissipative framework. The results highlight the stabilizing effect of the energy dependent damping and its interaction with the critical wave dynamics.

Finite Time Extinction and Stabilization for the Defocusing Schrödinger Equation with Localized Damping

Schedule: July 8 9:30-10:00 Room 314

Wellington J Correa

Federal Technological University of Parana, Brazil

Abstract:

In this paper, we study the existence and finite time extinction of solutions to a defocusing nonlinear Schrödinger equation on a smooth bounded domain as well as on the whole space and on an exterior domain. Initially, we construct approximate solutions within the framework of monotone operator theory. By employing multiplier methods and a unique continuation property, we establish that these approximations decay exponentially in the L^2 -norm. Subsequently, through a limit passage using weak lower semicontinuity, we prove both global existence, L^2 -decay, and finite time extinction for solutions of the original model. Furthermore, depending on the spatial dimension and the regularity of the solutions, we prove two distinct asymptotic behaviors: finite time extinction is achieved for weak solutions if $N = 1$ employing a localized damping. Finite time extinction is also obtained for regular solutions if $N < 4$ with a distributive damping. In both situations, exponential stabilization is obtained in the remaining cases. To the best of our knowledge, the present paper is the first to establish finite time extinction for systems featuring a non-constant damping across bounded and unbounded domains, generalizing the works of \cite{Jesus1}, \cite{Jesus2}, \cite{Jesus3}, \cite{Gallo}, and \cite{Carles}. Finally, an efficient numerical algorithm is implemented to computationally verify the theoretical finite time extinction. The ensuing simulations confirm the efficacy of the proposed localized control design.

Asymptotic behaviour of the viscoelastic wave equation

Schedule: July 7 18:00-18:30 Room 314

Valeria Domingos Cavalcanti

Universidade Estadual de Maringa - State University of Maringa, Brazil

Abstract:

We are concerned with the global existence of solutions as well as the decay rates for the viscoelastic wave equation in the past history framework.

Biological Concepts of Random Dynamical Systems in Infinite Dimension

Schedule: July 8 9:00-9:30 Room 314

Marcia Federson

Universidade de Sao Paulo, Brazil

Abstract:

We investigate biological concepts such as persistence, permanence, and extinction within the framework of random dynamical systems in infinite-dimensional settings. Focusing on asymptotically random cocycles, we establish structural properties of the associated random attractors, including existence, compactness, invariance, minimality, and connectedness under suitable assumptions. These results provide a rigorous foundation for describing the long-term behavior of randomly evolving populations. In particular, we show how the qualitative features of random attractors can be used to characterize persistence and extinction phenomena, thereby linking dynamical properties with biologically meaningful outcomes. This approach offers a unified perspective for analyzing population dynamics under randomness in infinite-dimensional spaces.

Stability for non-autonomous degenerate wave equations.

Schedule: July 7 17:30-18:00 Room 314

GENNI FRAGNELLI

University of Siena, Italy

Abstract:

We consider a non-autonomous wave equation on $(0, 1)$ with degeneracy at $x = 0$. Obviously, the presence of a non-autonomous term and of a degenerate function leads us to use different spaces with respect to the standard ones and it gives rise to some new difficulties. However, thanks to some suitable assumptions on the functions, one can prove some estimates on the associated energy that are crucial to obtain a uniform exponential decay.

Decay Properties of Higher-Order KdV-Type Systems with Dissipation and Time Delay

Schedule: July 8 16:30-17:00 Room 314

Fernando Gallego

Universidad Nacional de Colombia, Colombia

Co-Author(s): Roberto Capistrano, Vilmos Komornik

Abstract:

In this talk, we analyze the decay properties of a class of higher-order nonlinear dispersive systems with time delay, extending classical models of KdV--Burgers type to a more general setting. The equations under consideration incorporate both dispersive and dissipative effects, together with a delayed feedback term acting on the dynamics. We show that the presence of delay can still lead to exponential decay of solutions under suitable structural conditions on the feedback coefficients. In particular, stabilization is achieved without imposing sign restrictions on the instantaneous damping term, highlighting the effective role of the delayed mechanism. In addition, we discuss the behavior of the system in the absence of delay and establish general decay results in Sobolev spaces, covering a broad range of regularity. The results provide a unified qualitative framework for understanding the interplay between dispersion, dissipation, and memory effects in higher-order evolution equations posed on unbounded domains.

Long-time dynamics of KdV-KdV systems

Schedule: July 7 17:00-17:30 Room 314

Victor Hugo Gonzalez Martinez

Universidade Federal de Pernambuco, Brazil

Abstract:

The boundary stabilization problem of the Boussinesq KdV-KdV type system is investigated in this talk. An appropriate boundary feedback law consisting of a linear combination of a damping mechanism and a time-varying delay term is designed. Then, under a small restriction on the length of the spatial domain and the initial data, we show that the energy of the KdV-KdV system decays exponentially.

Supraconvergence and supercloseness in non-Fickian diffusion

Schedule: July 8 17:00-17:30 Room 314

Elias A Gudino

Federal University of Parana, Brazil

Abstract:

Controlled Drug Delivery Devices (CDD) have demonstrated superior therapeutic performance compared to conventional drug delivery systems (DD). Progress in materials science and bio-nanotechnology has enabled the development of more advanced CDD platforms, enhancing targeted delivery while reducing adverse side effects. From the mathematical point of view, the description of the drug delivery from a CDD poses several challenges, including selecting appropriate materials and understanding their impact on release kinetics, as well as accurately describing drug transport within the target tissue. From a numerical perspective, the development of stable and accurate methods capable of simulating the drug delivery process also presents significant challenges. In this talk we will focus on the mathematical modeling, numerical simulation and numerical analysis of drug release kinetics from matrix systems. Specifically, the transport of small molecules through a polymeric material. In this context, we assume that a fluid diffuses into a swelling matrix and causes a deformation, which induces a stress-driven diffusion and consequently a non-Fickian mass flux. Other multiphysics scenarios will be considered where similar results are established for diffusion processes enhanced by temperature. Numerical results illustrating the behavior of the models and the obtained theoretical results will be presented.

Qualitative Properties of Composite-Structures and Fluid Interaction PDE Models

Schedule: July 7 14:30-15:00 Room 314

Pelin Guven Geredeli

Clemson University, USA

Co-Author(s): Robert Denk

Abstract:

We consider the dynamics of composite structure-fluid interaction (FSI) PDE system. The coupling of 3D Stokes and 3D elastic dynamics is realized via an additional 2D elastic equation on the boundary interface. We analyze the (strong) stability and the exponential instability properties of the solution by way of analyzing the spectrum of the corresponding semigroup generator. We particularly appeal to Stone's Theorem and linear perturbation theory for the lack of exponential decay of the said coupled PDE system. This is a joint work with Robert Denk (University of Konstanz).

Instability results for Volterra-Stieltjes integral equations

Schedule: July 8 14:00-14:30 Room 314

Jaqueline Mesquita

Universidade Estadual de Campinas, Brazil

Co-Author(s): Rogelio Grau, Jucileide dos Santos

Abstract:

In this lecture, we will introduce the general class of functional Volterra Stieltjes integral equations and discuss how these equations can be connected to other types of equations. We will also present some results concerning instability for this class of equations.

On the Global Existence and Energy Decay of a Logarithmically Damped Wave Equation

Schedule: July 8 15:00-15:30 Room 314

Salim Messaoudi

University of Sharjah, United Arab Emirates

Co-Author(s): Muhammad Al-Gharabli

Abstract:

This paper investigates a wave equation in the presence of nonlinear logarithmic damping. We present, for the first time, a comprehensive and rigorous proof of the global existence of weak solutions for this class of problems. The analysis is carried out using the Faedo-Galerkin approximation method. This result establishes a robust foundational framework for future studies involving logarithmic dampings. In addition, we prove that the energy of the system decays at a polynomial rate as time progresses, by employing a suitable multiplier method adapted to the structure of the logarithmic dissipation. Our findings contribute to the deeper understanding of stabilization mechanisms in nonlinear wave models and offer new insights into the role of logarithmic damping in the long-time behavior of solutions.

Energy decay for Korteweg-de Vries-Burgers type equations with delay feedback

Schedule: July 7 16:30-17:00 Room 314

Cristina Pignotti

University of L'Aquila, Italy

Co-Author(s): Ibtissam Issa

Abstract:

We consider generalized KdV-Burgers equations on the real line with indefinite damping and time delay. By combining semigroup methods with suitable Lyapunov functionals, we prove well-posedness and derive exponential decay estimates under different settings.

Exact Interior Controllability of Magnetoelastic Plates Using Purely Magnetic Actuation

Schedule: July 7 15:00-15:30 Room 314

Buddhika Priyasad

University of Konstanz, Germany

Co-Author(s): Reinhard Racke

Abstract:

We establish exact interior controllability for a two-dimensional magnetoelastic plate system with control acting solely in the magnetic field equation. The main result shows that the coupled system is exactly controllable in arbitrarily small time $T > 0$, even though the control influences only the magnetic dynamics. This extends the principle of indirect control - previously observed in thermoelastic systems - to the magnetoelastic setting, demonstrating that the mechanical plate displacement can be steered using magnetic actuation alone. The analysis uses an operator-theoretic multiplier method adapted to handle the coupling between the mechanical and magnetic components. The proof consists of three main steps: establishing trace regularity for the adjoint system, deriving a suitable energy estimate, and applying a compactness-uniqueness argument to remove lower-order terms. This work provides the first exact controllability result for magnetoelastic systems and extends the indirect control framework from thermoelasticity to this setting. The techniques developed here are relevant for the control-theoretic study of magnetically coupled elastic structures, with potential applications in smart materials and electromagnetic actuators.

A Direct Approach for Detection of Bottom Topography in Shallow Water

Schedule: July 8 8:00-8:30 Room 314

Carole Rosier

University of Littoral, France

Co-Author(s): Nouredine Lamsahel

Abstract:

We propose a fast, stable, and direct analytic method to detect underwater channel topography from surface wave measurements, based on one-dimensional shallow water equations. The technique requires knowledge of the free surface and its first two time derivatives at a single instant t^* above the fixed, bounded open segment of the domain. We first restructure the forward shallow water equations to obtain an inverse model in which the bottom profile is the only unknown, and then discretize this model using a second-order finite-difference scheme to infer the floor topography. We demonstrate that the approach satisfies a Lipschitz stability estimate and is independent of the initial conditions of the forward problem. The well-posedness of this inverse model requires that, at the chosen measurement time t^* , the discharge be strictly positive across the fixed portion of the open channel, which is automatically satisfied for steady and supercritical flows. For unsteady subcritical and transcritical flows, we derive two empirically validated sufficient conditions ensuring strict positivity after a sufficiently large time. The proposed methodology is tested on a range of scenarios, including classical benchmarks and different types of inlet discharges and bathymetries.

Null controllability of strongly degenerate parabolic equations

Schedule: July 7 15:30-16:00 Room 314

Lionel ROSIER

Universite du Littoral Cote d'Opale, France

Co-Author(s): Antoine Benoit and Romain Loyer

Abstract:

We consider linear one-dimensional strongly degenerate parabolic equations with measurable coefficients that may be degenerate or singular. Taking 0 as the point where the strong degeneracy occurs, we assume that the coefficients $a = a(x)$ in the principal part of the parabolic equation is such that the function $a^{-1} > x/a(x)$ is in $L^p(0, 1)$ for some $p > 1$. After establishing some spectral estimates for the corresponding elliptic problem, we prove that the parabolic equation is null controllable in the energy space by using one boundary control.

Interacting flexible structures with localized strong damping: Semigroup stability and regularity

Schedule: July 8 17:30-18:00 Room 314

LOUIS TEBOU

Florida International University, USA

Co-Author(s): Irena Lasiecka, Kais Ammari, Fathi Hassine and Souleymane Kadri Harouna

Abstract:

Thanks, first to a conjecture of Goong Chen and David Russell (1982), then to results of Roberto Triggiani and Shuping Chen (1989, 1990), responding to that conjecture, it has been known since the late eighties that the Euler-Bernoulli plate with structural or Kelvin-Voigt damping exhibits an analytic and exponentially stable semigroup. Then came the natural question: What happens to these semigroup properties when the structural or Kelvin-Voigt damping is localized? In the late nineties, Kangsheng Liu and Zhuangyi Liu (1998) showed that the semigroup corresponding to an Euler-Bernoulli beam with localized Kelvin-Voigt damping is exponentially stable, but not analytic; in the same paper, those authors proved that the string equation with localized Kelvin-Voigt damping is not exponentially stable when the damping coefficient is discontinuous. In this talk, I'll give a brief historical account of what is known in this framework, then share recent findings with my collaborators Irena Lasiecka (case of Euler-Bernoulli plate with localized structural or Kelvin-Voigt damping), and Kais Ammari, Fathi Hassine and Souleymane Kadri Harouna (case of coupled wave equations with localized singular Kelvin-Voigt damping).

On the Long-time Stability of the Implicit Euler Scheme for a Two-phase Flow Model

Schedule: July 7 14:00-14:30 Room 314

Florentina Tone

University of West Florida, USA

Co-Author(s): Theodore Tachim

Abstract:

We present results on the stability for all positive time of the fully implicit Euler scheme for an incompressible two-phase flow model. More precisely, we consider the time discretisation scheme and with the aid of the discrete Gronwall lemma and of the discrete uniform Gronwall lemma we prove that the numerical scheme is stable.

Stationary solutions for the wave equation with hyperbolic boundary conditions

Schedule: July 8 13:30-14:00 Room 314

Enzo Vitillaro

Dipartimento di Matematica e Informatica Università degli Studi di Perugia, Italy

Abstract:

We deal with standing waves for the wave equation with hyperbolic boundary conditions, posed in a bounded domain with regular boundary. These problems possess a wide literature, including the papers on Arch. Rat. Mech. Anal. (2017), J.D.E. (2018) and DCDS-S (2021) by the author. Stationary solutions of these evolution problems turn out to be solutions of a doubly elliptic problem posed in the domain. This problem involved the Laplace operator inside the domain, the Laplace--Beltrami operator at the boundary, and up to two nonlinear sources, one inside the domain, the other one at the boundary. This type of problem has been studied by the author in a paper on Comm. Anal. Mech (2023) in presence of a single homogeneous boundary source. In this talk we discuss the more involved case of two nonlinear, possibly vanishing and nonhomogeneous, sources, which can also involve linear terms. In particular, we shall characterize in several ways the potential--well depth, by also proving the existence of solutions at this level. Finally, we shall also give multiplicity results for stationary solutions.

Special Session 99 : Emerging Trends in Analysis and Control of PDEs

Organizer(s): Diego A. Souza , Anna Doubova , K  vin Le Balc'h

Introduction: The control of systems governed by Partial Differential Equations (PDEs) is a fundamental branch of mathematics that studies how to influence dynamical systems to ensure they behave in a desired manner. This influence is exerted through appropriate inputs — applied either on the boundary or within the domain — aiming to drive the system toward a target state (controllability), maintain its stability (stabilization), or minimize a prescribed cost functional (optimal control). This special session will focus on recent advances in the analysis and control of both linear and nonlinear system of PDEs. We aim to highlight emerging trends and open problems, while fostering interdisciplinary dialogue and collaboration. By bringing together a diverse group of researchers—ranging from early-career scholars to established experts—we believe this convergence of experience and new perspectives will encourage meaningful interactions and contribute to the continued development of this field.

Control and Energy Decay in Wave Networks with N-Inertial Interfaces.

Schedule: July 7 17:00-17:30 Room 425

Mohammad Akil

Universit  Polytechnique Hauts de France, France

Co-Author(s): Ibtissam Issa, Ahmet Ozkan Ozer and Cristina Pignotti

Abstract:

In this talk we study the asymptotic behavior and stability of a system of $N + 1$ serially connected wave equations on adjacent intervals, coupled through N inertia-generating effects at interior junctions. In contrast to earlier works limited to boundary feedback, we consider internal damping applied at different locations along the network and examine how the spatial distribution of these damping mechanisms influences the overall stability. The analysis reveals that both the presence and placement of damping significantly affect the rate of energy decay. The results establish new connections between damping configuration and asymptotic behavior, providing a comprehensive analytical approach to the stabilization of distributed systems with pointwise inertia.

Inverse problems for Kelvin--Voigt viscoelastic and Moore--Gibson--Thompson equations

Schedule: July 6 14:30-15:00 Room 425

Jone Apraiz

University of the Basque Country, Spain

Co-Author(s): Rodrigo Lecaros (Federico Santa Marí\`{i}a Technical University, Chile) and Sebasti\`{a}n Zamorano (University of Deusto, Spain).

Abstract:

In this talk we will consider inverse coefficient problems for two evolution models with relaxation structure: a Kelvin--Voigt viscoelastic system and the Moore--Gibson--Thompson equation arising in nonlinear acoustics. In both cases, we will establish Lipschitz stability estimates for the recovery of a space-dependent damping coefficient from a single measurement. This research extends Carleman-based inverse theory to third-order-in-time acoustic models and provides a unified framework for inverse problems in relaxation-type evolution equations. This is a joint research project in collaboration with Rodrigo Lecaros (Federico Santa Marí\`{i}a Technical University, Chile) and Sebasti\`{a}n Zamorano (University of Deusto, Spain).

Analysis and Control in Poroelastic Systems with Applications to Biomedicine

Schedule: July 7 14:00-14:30 Room 425

Lorena Bociu

NC State University, USA

Abstract:

In biomechanics, local phenomena, such as tissue perfusion, are strictly related to the global features of the surrounding blood circulation. We propose a heterogeneous model where a local, accurate, 3D description of fluid flows through deformable porous media by means of poroelastic systems is coupled with a systemic 0D lumped model of the remainder of the circulation. This represents a multiscale strategy, which couples an initial boundary value problem to be used in a specific region with an initial value problem for the rest of the circulatory system. We present new results on wellposedness analysis and control for this nonlinear multiscale interface coupling of PDEs and ODEs.

Spectral inequality for the n -dimensional Stokes operator with $n-1$ observation terms.

Schedule: July 7 15:30-16:00 Room 425

Felipe W. Chaves-Silva

Federal University of Paraíba, Brazil

Co-Author(s): M. G. Ferreira-Silva, D. A. Souza

Abstract:

In this talk, we present a new spectral inequality for the low frequencies of the Stokes operator, obtained by observing only $n-1$ components of the velocity field. As a consequence, we show that the cost of driving the solution of the evolutionary Stokes system to zero at a given time, using controls acting on $n-1$ components, is of the same order as the cost corresponding to controls acting on all components of the system.

Reconstruction of degeneracy region and power for parabolic equations and systems

Schedule: July 7 17:30-18:00 Room 425

Veronica Danesi

University of Rome Tor Vergata, Italy

Abstract:

In this talk, we will address the inverse problem of recovering a degeneracy region within the diffusion coefficient of a parabolic equation by observing the normal derivative at the boundary. The strongly degenerate case is analyzed and our method is based on a careful analysis of the spectral problem. In particular, we derive sufficient conditions on the initial data that guarantee stability and uniqueness of the solution obtained from a one-point measurement. Moreover, we present more general uniqueness theorems, which also cover the identification of the initial data and the degeneracy power, using measurements taken over time. Our investigations cover the case of real 1-D degenerate parabolic systems of equations with a specific coupling. Besides, possible extensions to multidimensional parabolic equations will be also analyzed. Theoretical results are also supported by numerical simulations. This talk is based on works in collaboration with P. Cannarsa and A. Doubova.

Controllability of a one-dimensional debonding model

Schedule: July 6 18:00-18:30 Room 425

Nicola De Nitti

University of Pisa, Italy

Co-Author(s): N. De Nitti, A. Shao

Abstract:

We investigate a one-dimensional dynamic debonding model, introduced by Freund (1990), in which the wave equation is coupled with a Griffith criterion governing the propagation of the fracture. In particular, we study the boundary controllability of the system to a prescribed target state. Our main results provide precise characterizations of the reachable target states, in both $C^{0,1}$ and C^1 regularity settings, and construct exact controls toward these target states.

Exponential stability of a generalised Burgers equation in a n-dimensional torus

Schedule: July 7 15:00-15:30 Room 425

Imene DJEBOUR

CY Cergy Paris Universite, France

Abstract:

We study a generalized conservative Burgers equation on a n -dimensional torus. We first consider the associated linear system. By exploiting the Harnack inequality and the L^1 contraction property, we establish exponential stability in the L^1 norm. For the nonlinear problem, we derive a uniform-in-time estimate of the solution using the De Giorgi-Nash-Moser iteration method. Moreover, we show that the Hölder norm of the solution remains uniformly bounded and decays exponentially.

Null controllability for a degenerate Fokker-Planck equation with a drift term

Schedule: July 6 15:00-15:30 Room 425

GENNI FRAGNELLI

University of Siena, Italy

Co-Author(s): Dimitri Mugnai

Abstract:

The Fokker-Planck equation describes the time evolution of the probability density function of the velocity for a particle under the influence of drag forces and random forces. In particular, this equation has multiple applications in information theory, graph theory, data science, finance, economics... In one spatial dimension the Fokker-Planck equation for the probability density $p(t, x)$ can be rewritten as

$$p_t(t, x) - (a(t, x)p(t, x))_{xx} + (\mu(t, x)p(t, x))_x = f(t, x)$$

where $t \in [0, T]$, $T > 0$ is fixed and $x \in (0, 1)$. In this talk we assume that a is a function degenerating at $x = 0$; the purpose is to study the null-controllability of the solution, namely the possibility to drive the solution p to rest completely at time T .

Stability and Well-Posedness of Korteweg-de Vries-Burgers Equations with Delayed Feedback

Schedule: July 6 18:30-19:00 Room 425

Ibtissam Issa

University of L'Aquila, Italy

Abstract:

This talk is devoted to the analysis of generalized Korteweg-de Vries-Burgers equations with delayed feedback and damping. Using semigroup methods and Lyapunov techniques, we establish well-posedness results and investigate the long-time behavior of solutions. In particular, we derive exponential decay estimates under suitable assumptions on the delay term and the system parameters. The analysis highlights how delay effects influence stability properties and provides conditions ensuring robust stabilization, even in challenging settings.

Fredholm backstepping for self-adjoint operators and applications to the rapid stabilization of parabolic and fractional parabolic equations in arbitrary dimensions

Schedule: July 7 18:00-18:30 Room 425

Nazim Kacher

Sorbonne Universite, France

Co-Author(s): Ludovick Gagnon, Hoai-Minh Nguyen

Abstract:

In this talk, we address the Fredholm backstepping for self-adjoint operators in any dimension. This method of stabilization links an equation needing to be stabilized to an already stable equation, via an invertible transformation T . This method was until now restricted to 1D. This is because one had to deal with series that do not converge in dimension 2 or higher, due to the growth of the eigenvalues. In this talk, we will see how the introduction of a spectral projection gets rid of these difficulties, and allows us to apply this method to parabolic equations in all dimension. The growth condition of the spectrum and the gap condition is now relaxed. As an application, we establish the rapid stabilization of the heat and fractional heat equation $(-\Delta^s)$ with $s \in (0, 1]$ from measurable or open sets in arbitrary dimensions

Exact output tracking of the 1-d heat equation

Schedule: July 7 14:30-15:00 Room 425

Pierre Lissy

CERMICS, Ecole nationales des ponts et chaussées, France

Co-Author(s): Lucas Davron

Abstract:

In this talk, I will address an exact output tracking problem (or sidewise control problem) for the one-dimensional heat equation on a bounded interval, with Neumann boundary conditions. The control is a Neumann control on the left of the interval, whereas the output is the Dirichlet trace at the right-hand side of the interval. We aim at characterizing all the possible outputs when the control u lives in the space $L^2(0, T)$ for a finite or infinite T . In this setting, we obtain an exact characterization of all the trackable outputs. In infinite time, they form some kind of Gevrey class, whereas in finite time, some auxiliary power series involving the derivative of the signals in time T needs also to belong to the reachable space. The proof is based on applying the Laplace transform in time, and notably on some auxiliary lemmas on the Hardy spaces that might be interested by themselves, and some kind of Plancherel formula. If time permits, I will explain the link with some classical problems in real analysis, namely, the interpolation problems in some Gevrey classes.

Sharp geometric conditions for the controllability of magnetic Schrödinger equations

Schedule: July 6 14:00-14:30 Room 425

Fabricio Macia

Universidad Politecnica de Madrid, Spain

Abstract:

In this talk, we will present necessary and sufficient conditions for the controllability of Schrödinger equations with electromagnetic potential. It is well known that such equations are controllable from an open set ω whenever it satisfies the geometric control condition; in that case, one has controllability for any time $T > 0$. We show that this result can be improved on the sphere $\mathbb{S}^2$: in this setting, the system is controllable if ω satisfies a magnetic-field-dependent geometric control condition, which is weaker than the geometric control condition. Under this condition, there exists a minimum time, depending on the magnetic potential, beyond which the system is controllable. This geometric condition, and the minimum control time, are necessary for controllability as well. This is joint work with Gabriel Riviere (Nantes).

A method to determine the minimal null control time of one-dimensional linear hyperbolic systems

Schedule: July 6 17:00-17:30 Room 425

Guillaume Olive

Jagiellonian University, Poland

Abstract:

In this talk, we address the problem of null controllability for one-dimensional first-order linear hyperbolic systems of the form:

$$\left\{ \begin{array}{l} \frac{\partial y}{\partial t}(t, x) + \Lambda(x) \frac{\partial y}{\partial x}(t, x) = M(x)y(t, x), \quad y_-(t, 1) = u(t), \quad y_+(t, 0) = Qy_-(t, 0), \quad y(0, x) = y^0(x), \\ (t, x) \in (0, T) \times (0, 1), \end{array} \right.$$

where $u : (0, T) \rightarrow \mathbb{R}^m$ is the control. We present a method to find the minimal control time when the coefficients are regular enough. This presentation is based on a joint work with Long Hu (<https://doi.org/10.1016/j.jde.2025.113455>)

Time-delayed opinion dynamics with leader-follower interactions

Schedule: July 6 16:30-17:00 Room 425

Cristina Pignotti

University of L'Aquila, Italy

Co-Author(s): Young-Pil Choi, Chiara Cicolani

Abstract:

We study time-delayed variants of the Hegselmann-Krause opinion formation model. In particular, we focus on a model featuring a small group of leaders and a large group of non-leaders. In our model, leaders influence all agents but only interact among themselves, while non-leaders update their opinions via interactions with both their peers and the leaders, with time delays accounting for communication and decision-making lags. We prove that the system achieves consensus with an exponential decay rate and establish uniform l_∞ -stability with exponentially decaying transients. Furthermore, we analyze the mean-field limit in two regimes: (i) with a fixed number of leaders and an infinite number of non-leaders, and (ii) with both populations tending to infinity, obtaining existence, uniqueness, and exponential decay estimates for the corresponding macroscopic models.

Steady Self-Propelled Motion of a Rigid Body in a Viscous Fluid with Navier-Slip Boundary Conditions

Schedule: July 6 15:30-16:00 Room 425

Arnab Roy

Basque Center for Applied Mathematics (BCAM), Spain

Co-Author(s): Šárka Nečasová and Ana Leonor Silvestre

Abstract:

In this talk, we consider the steady self-propelled motion of a rigid body immersed in a three-dimensional incompressible viscous fluid governed by the Navier-Stokes equations. Under suitable smallness assumptions on the boundary flux and on the normal component of the prescribed surface velocity, we establish the existence of weak steady solutions to the coupled fluid-structure system. Beyond existence, we provide a necessary and sufficient condition under which a prescribed slip velocity on the body surface induces nontrivial translational or rotational motion of the rigid body. This is achieved through the introduction of a finite-dimensional control thrust space, defined via auxiliary exterior Stokes problems with Navier boundary conditions, which captures the effective contribution of boundary-driven flows to the rigid-body motion. Our results clarify how boundary effects generate propulsion and extend the classical Dirichlet-based theory to the Navier-slip setting.

Controlling Klein-Gordon Chains and Lattices

Schedule: July 6 17:30-18:00 Room 425

Sarah Strikwerda

University of Wisconsin - Madison, USA

Co-Author(s): Hung Vinh Tran and Minh-Binh Tran

Abstract:

The Klein-Gordon equation is a wave equation with a cubic nonlinearity. This system can be used to describe the interaction of particles on a lattice. I will describe a suitable choice of feedback control to drive the system to a collective flocking behavior in finite time. Finally, I will highlight the connection between our flocking problem and a minimal-time problem in the framework of nonlinear Hamilton-Jacobi equations and optimal control theory.

Controllability properties of coupled PDEs

Schedule: July 7 13:30-14:00 Room 425

Emmanuel TRELAT

Sorbonne University, France

Co-Author(s): Hugo Lhachemi, Christophe Prieur, Emmanuel Trélat

Abstract:

In a series of works with Hugo Lhachemi and Christophe Prieur, we investigate the controllability properties of some coupled PDEs, which can be of different natures. For a heat-wave PDE with coupling at the boundary, we establish exact, exact null and approximate controllability in appropriate Hilbert spaces, under sharp assumptions. Our approach relies on an Ingham-Müntz inequality, allowing us to establish an observability inequality for the dual problem. The resulting controllability space, which depends on the coupling function and is characterized in a spectral way, is not a usual functional space. I will also give some results for other cascade systems, providing new results for coupled heat equations where interesting changes happen at some specific times in the controllability properties.

Recent advances on approximate trajectory controllability. Application to the enhanced dissipation of a passive scalar.

Schedule: July 6 13:30-14:00 Room 425

Marius Tucsnak

University of Bordeaux, France

Abstract:

Given a continuous-time control system and $\varepsilon > 0$, we address the question of the existence of controls that maintain the corresponding state trajectories within the ε -neighborhood of any prescribed path in the state space. We first investigate this property, called approximate tracking controllability, in the linear finite-dimensional case, when our answers are negative: we demonstrate that approximate tracking controllability of the full state is impossible even in a certain weak sense, except for trivial situations. For finite-dimensional systems with quadratic nonlinearities, we prove approximate tracking controllability on any time horizon with respect to the relaxation metric. This approach is next generalized for a PDE system: the Euler equations with distributed control. We underline the relevance of this weak setting by developing applications to coupled systems and by remarking obstructions that would arise for natural stronger norms. The main application concerns obtaining the enhanced dissipation of a passive scalar using a controlled fluid flow.

Small-Time Approximate and Exact Controllability for Nonlinear Parabolic Equations with Bilinear Controls

Schedule: July 7 16:30-17:00 Room 425

Cristina Urbani

Universitas Mercatorum, Italy

Abstract:

In this talk, we investigate the small-time controllability of a class of nonlinear parabolic evolution equations posed on a torus of arbitrary dimension and driven by bilinear control terms. Assuming an appropriate saturation condition on the potential, we prove a small-time approximate controllability result between states that share the same sign. In the one-dimensional setting, this result can be strengthened by coupling it with a local exact controllability property. This combined approach yields small-time exact controllability from any positive initial state to the ground state of the associated evolution operator.

Special Session 101 : Applied Dynamical Systems in Action

Organizer(s): Thomas Hagen , Florian Rupp

Introduction: This Special Session will convene leading experts in both low- and infinite-dimensional Dynamical Systems, facilitating meaningful cross-disciplinary discussions. The central focus is on non-linear dynamics, encompassing stability, bifurcation, blow-up and asymptotics, and may involve deterministic as well as stochastic or random effects. Particular attention is given to phenomena observed in real-world applications, highlighting their significance and practical implications.

Higher order approximations to the (dual) semi-geostrophic equation

Schedule: July 6 15:00-15:30 Room 438

Ioannis Giannoulis

University of Ioannina, Greece

Co-Author(s): Vasileios Kalivopoulos

Abstract:

The semi-geostrophic equation is a reduced model for the approximate description of large-scale atmospheric or oceanic flows. The corresponding Lagrangian flow is measure preserving and the density of this image measure is evolved by a transport equation with a velocity field that is determined through the solution of a Monge-Ampere equation where the right hand side is the transported density. This coupled system is the so called dual semi-geostrophic equation for which the global existence of smooth solutions is still open. On the other hand, by a suitable linearization of the Monge-Ampere equation one obtains a Poisson equation and hence, in two dimensions, the dual semi-geostrophic equation is formally approximated by the Euler vorticity equation which has globally smooth solutions. G. Loeper made this approximation result rigorous to leading order on time scales of order $O(1/\varepsilon)$ with an error of order $O(\varepsilon)$. We present a generalization of this result for higher order approximations with the higher order correction terms being determined by nonlocal linear inhomogeneous transport equations. This allows us to reduce the order of the error to $O(\varepsilon^k)$ for arbitrary $k \in \mathbb{N}$. This work is supported by the Hellenic Foundation for Research and Innovation (HFRI).

Semiflow Structure in Viscous Fiber Dynamics

Schedule: July 6 18:00-18:30 Room 438

Thomas Hagen

The University of Memphis, USA

Abstract:

We study a one dimensional dynamical system describing viscous fiber stretching, arising from industrial fiber spinning processes in which a highly viscous fluid is drawn into a thin filament. The model is obtained by cross sectional averaging of the axisymmetric Stokes equations with a free boundary and yields a coupled nonlinear evolution for mass transport and momentum balance dominated by viscous forces. Using a Lagrangian formulation, we derive a representation of the fiber cross sectional area that ensures forward invariance of positivity, rules out finite time breakup, and allows continuation of local solutions to global ones, yielding existence and uniqueness of the induced semiflow. The presentation addresses extensions to nonisothermal models, where temperature dependent viscosity couples the dynamics to a temperature equation and introduces a moving boundary formulation. We highlight which elements of the Lagrangian approach continue to govern global evolution and which require modification due to thermal coupling and boundary motion.

Brain Imaging and Mathematical Modeling of Alzheimer's Disease

Schedule: July 6 17:00-17:30 Room 438

Peter Hinow

University of Wisconsin - Milwaukee, USA

Co-Author(s): Dr. Muna Aryal (North Carolina Agricultural and Technical State University), Micah Hesketh (graduate student, UWM)

Abstract:

A wide variety of medical imaging methods exist for research and diagnostic procedures on the Central Nervous System (CNS), among them Magnetic Resonance Imaging (MRI) and Optical Imaging. Mathematical modeling and simulation contribute significantly to an improved understanding of image data and the intricate transport, diffusion, and metabolic processes in the brain. This is of particular importance in the study of pathologies such as Alzheimer's Disease, which, 125 years after its description, remains poorly understood and for which only moderate success has been made in its treatment. In the first work to be presented, we investigate tracer diffusion and transport in the glymphatic system by combining optical imaging in rats with a partial differential equation of reaction-advection-diffusion type. In a second work, we collect observations on the accumulation of amyloid- β , changes in neuronal density, and a decline in cognitive performance in TgF344-AD and wild-type rats. We develop a compartmental ordinary differential equation model and determine its parameters by fitting the output to the experimental observations. In the long run, our mathematical modeling effort is intended to bridge AD research in rodent models and the human condition of AD.

Geometric properties of rough curves via dynamical systems: SBR measure and local time

Schedule: July 6 14:30-15:00 Room 438

Peter Imkeller

Humboldt University at Berlin, Germany

Co-Author(s): Olivier Pamen, Frank Proske

Abstract:

We investigate geometric properties of graphs of Takagi and Weierstrass type functions, represented by series based on smooth functions. They are Hölder continuous, and can be embedded into smooth dynamical systems, where their graphs emerge as pullback attractors. It turns out that occupation measures and Sinai-Bowen-Ruelle (SBR) measures on their stable manifolds are dual by "time" reversal. Hence absolute continuity of the SBR measure is seen to be dual to the existence of local time. The link between the rough curves considered and smooth dynamical systems can be generalized in various ways. For instance, Gaussian randomizations of Takagi curves just reproduce the trajectories of Brownian motion. Applications to regularization of singular ODE by rough signals are envisaged. This is joint work with O. Pamen (U Liverpool and AIMS Ghana) and F. Proske (U Oslo).

Analysis of a PDE model for ant trail formation

Schedule: July 6 17:30-18:00 Room 438

Matthias Rakotomalala

Technical University of Munich, Germany

Co-Author(s): Charles Bertucci, Milica Tomasevic, Oscar de Wit

Abstract:

We introduce a new chemotaxis model motivated by ant trail pattern formation, formulated as a coupled parabolic-parabolic PDE system describing the evolution of the population density and the chemical signal. The key novelty lies in the transport term for the population, which depends on second-order derivatives of the chemical field. This term is derived as the limit of an anticipation-reaction mechanism for an infinitesimally small ant. We establish global existence and uniqueness of solutions, as well as the propagation of the regularity of the initial data. We then analyze the long-time behavior of the system: we prove the existence of the compact global attractor and show that the homogeneous steady state becomes nonlinearly unstable under an inviscid instability criterion. Additionally, we provide a lower bound on the dimension of the attractor. Conversely, we prove that for sufficiently small interaction strength, the homogeneous steady state is globally asymptotically stable. Finally, we present several numerical simulations illustrating the model's dynamics.

Mathematical Analysis of the Dynamics in the Tobacco Plant v.s. Moth Interaction Cycle

Schedule: July 6 15:30-16:00 Room 438

Florian Rupp

Kutaisi International University, Germany

Abstract:

Plant-herbivore systems provide a natural laboratory for nonlinear dynamical phenomena arising from feedback, adaptation, and multi-scale interaction. In this paper, we develop and analyze a mathematical model for the intra- and inter-species dynamics governing the interaction between the wild tobacco plant (*Nicotiana attenuata*) and the tobacco hawk moth and its caterpillars (*Manduca sexta*). Hereby special attention is given to plant defense mechanisms, i.e., nicotine production, attack signals to other tobacco plants, and signals to predator insects, like big-eyed bugs (several species in the family Geocoris), that feed on the caterpillars of the tobacco hawk moth. The resulting model is studied by techniques from the theory of dynamical systems such that conditions for stability and bifurcations of mixed-species equilibria are determined and the phase space dynamics are classified. Simulations round-up the picture. The model and its mathematical analysis illustrate how biochemical defense pathways translate into ecological phase portraits and provide a case study in how adaptive biological feedback adds to the insights of classical predator-prey dynamics.

Degenerate reaction diffusion systems arising in models for biofilm growth

Schedule: July 6 16:30-17:00 Room 438

Stefanie Sonner

Radboud University, Netherlands

Co-Author(s): J. Dockery, H.J. Eberl, V. Hissink Muller, J. Hughes, K. Mitra, S. Pop, R. Smeets

Abstract:

Biofilms are dense aggregations of bacterial cells in moist ecosystems that are held together by a self-produced slimy matrix and are often attached to a surface. We consider mathematical models for spatially heterogeneous biofilms that are formulated as quasilinear reaction diffusion systems. Their characteristic feature is the two-fold degenerate diffusion coefficient for the biomass density comprising a polynomial degeneracy (as the porous medium equation) and a fast diffusion singularity as the biomass density approaches its maximum value. This degenerate equation is coupled to semilinear parabolic equations and/or ordinary differential equations for nutrient concentrations and additional substrates. We present results on the well-posedness and regularity of solutions for such systems on bounded and unbounded domains. For systems with immobilized nutrients the existence of traveling wave solutions has been shown. Numerical simulations are presented to illustrate the model behaviour.

Deriving a thermodynamic system from a Hamiltonian one

Schedule: July 6 14:00-14:30 Room 438

Johannes Zimmer

TU Munich, Germany

Co-Author(s): Alexander Mielke and Mark Peletier

Abstract:

We reconsider the problem of coarse-graining a microscopic Hamiltonian dynamics which describes the motion of molecules to obtain a macroscopic system which includes dissipative mechanisms. In particular, we study the thermodynamical implications concerning Hamiltonians, energy, and entropy and the induced geometric structures. Randomness enters through the initial data of a heat bath component of the original Hamiltonian system. The analysis uses some mathematical tools from the theory of dilations, which will be described at the hand of an example. The main interest is, however, to analyse the resulting system in the formulation of GENERIC (General Equations for Non-Equilibrium Reversible Irreversible Coupling). We will show that the coarse-grained version has this structure, with conserved energy, nondecreasing entropy and an Onsager operator describing the dissipation. A particular interest will be to understand how the building blocks of GENERIC arise from the microscopic Hamiltonian system.

Special Session 102 : Mathematics of Cancer and Cardiovascular Dynamics: From High-Fidelity Simulation to Data-Driven Methods

Organizer(s): Nikolaos Sfakianakis , Zuzanna Szymańska , Niklas Kolbe

Introduction: This Special Session will focus on advancing mathematical and computational approaches to complex biomedical phenomena, with particular emphasis on cancer growth, metastasis, and cardiovascular dynamics. These processes span across several scales and are governed by nonlinear PDEs over intricate, heterogeneous domains, including vascular networks and realistic organ geometries. Such challenges require the interplay of mathematical modelling, numerical analysis, and data-driven methods. We shall invite contributions from Applied Mathematics, Computational Sciences, and Biomedical Engineering to address: - Multiscale and Nonlinear phenomena, e.g. tumor invasion and multi-organ blood-flow, requiring high-order discretisation schemes, e.g. numerical solvers for interface-rich problems with strong coupling across scales and Discontinuous Galerkin (dG) methods. - Complex organ-level-geometries, derived from Medical Imaging, that require advanced remeshing and simulation strategies, including Adaptive Mesh Refinement (AMR). - Parameter uncertainty, arising from measurement and patient variability, motivating Machine Learning (ML)-based data assimilation, and Biology/Physics-Informed Neural Networks (B/PINNs) for model calibration, surrogate modelling, and uncertainty quantification. - Inter-organ dynamics, particularly in metastasis, where modelling of tumour-vascular interactions and organ-to-organ transport involves coupling macroscopic PDEs with experimental data and probabilistic transition models. - Error control and computational efficiency, through a-posteriori error-estimation and AMR, with analytical approaches and modern heuristics to guide computational effort.

Data Driven Modeling of Pseudopalisade Pattern Formation

Schedule: July 6 15:00-15:30 Room 445

Sandesh Athni Hiremath

Rhinelandpfalz Technical University, Germany

Co-Author(s): Christina Surulescu

Abstract:

Pseudopalising is an interesting phenomenon where cancer cells arrange themselves to form a dense garland-like pattern. Unlike the palisade structure, a similar type of pattern first observed in schwannomas by pathologist J.J. Verocay, pseudopalises are less organized and associated with a necrotic region at their core. These structures are mainly found in glioblastoma (GBM), a grade IV brain tumor, and provide a way to assess the aggressiveness of the tumor. Identification of the exact bio-mechanism responsible for the formation of pseudopalises is a difficult task, mainly because pseudopalises seem to be a consequence of complex nonlinear dynamics within the tumor. In this paper we propose a data-driven methodology to gain insight into the formation of different types of pseudopalise structures. To this end, we start from a state of the art macroscopic model for the dynamics of GBM, that is coupled with the dynamics of extracellular pH, and formulate a terminal value optimal control problem. Thus, given a specific, observed pseudopalise pattern, we determine the evolution of parameters (bio-mechanisms) that are responsible for its emergence. Random histological images exhibiting pseudopalise-like structures are chosen to serve as target pattern. Having identified the optimal model parameters that generate the specified target pattern, we then formulate two different types of pattern counteracting ansatzes in order to determine possible ways to impair or obstruct the process of pseudopalise formation. This provides the basis for designing active or live control of malignant GBM. Furthermore, we also provide a simple, yet insightful, mechanism to synthesize new pseudopalise patterns by linearly combining the optimal model parameters responsible for generating different known target patterns. This particularly provides a hint that complex pseudopalise patterns could be synthesized by a linear combination of parameters responsible for generating simple patterns. Going even further, we ask ourselves if complex therapy approaches can be conceived, such that some linear combination thereof is able to reverse or disrupt simple pseudopalise patterns; this is investigated with the help of numerical simulations.

Hybrid PINN-FEM framework for tumor growth models with stabilization

Schedule: July 6 17:00-17:30 Room 445

Suleyman Cengizci

Antalya Bilim University, Turkey

Abstract:

This study presents a hybrid computational framework integrating physics-informed neural networks (PINNs) with stabilized finite element methods for simulating haptotaxis-driven cancer invasion dynamics. The governing equations consist of time-dependent, nonlinear, coupled partial differential equations describing cancer cell density, extracellular matrix (ECM) degradation, and matrix-degrading enzyme concentration. In convection-dominated regimes, standard Galerkin finite element methods produce spurious oscillations and nonphysical negative densities. To address this, we employ the streamline-upwind/Petrov--Galerkin (SUPG) formulation augmented with the $YZ\beta$ discontinuity-capturing technique to generate numerically stable reference solutions. A multi-phase adaptive PINN training strategy is then proposed, progressively transitioning from data-dominant learning using SUPG-- $YZ\beta$ solutions to physics-informed refinement through selective enforcement of governing equations. The neural network architecture incorporates Fourier feature embeddings and deep residual blocks to capture sharp tumor invasion fronts. Numerical experiments on benchmark haptotaxis models demonstrate that the hybrid approach eliminates nonphysical oscillations while achieving enhanced accuracy compared to standalone stabilized FEM, effectively resolving steep gradients characteristic of invasive tumor boundaries. The framework is implemented using FEniCS and PyTorch with GPU acceleration, providing a flexible tool for mathematical oncology applications.

Computational investigation of the interactions between oncolytic viruses and tumour-associated macrophages

Schedule: July 6 15:30-16:00 Room 445

Raluca EFTIMIE

University Marie and Louis Pasteur, France

Abstract:

The interactions between oncolytic viruses (OVs) and innate immunity are crucial for the success of oncolytic therapies. Here we focus on a heterogeneous and plastic population of innate immune cells, the tumour-associated macrophages, that can be involved in the elimination of OVs, as well as in the replication of OVs and their spread across tumour tissue. Computational approaches are used to investigate the importance of different biological mechanisms in the faster spread of OVs, as helped/hindered by different macrophage phenotypes.

Simple Mathematical Model of CAR-T Cells Therapy for Glioblastoma

Schedule: July 6 18:00-18:30 Room 445

Urszula Forys

University of Warsaw, Faculty of Mathematics, Informatics and Mechanics, Poland

Co-Author(s): Juan Belmonte-Beitia, Marek Bodnar, Mariusz Bodzioch, Monika J. Piotrowska, Magdalena Szafranska-
 \L{}c{e}czycka

Abstract:

CAR-T (chimeric antigen receptor T) cell therapy is a novel immunotherapy that oncologists are trying to adapt to various types of cancer, including glioblastomas - brain tumors of glial origin. We consider a generalisation of the mathematical model proposed by Le\`{o}n-Triana et al. (2021) describing the competition of CAR-T and glioblastoma tumour cells. We focus on the mathematical properties of the proposed model, analyzing the stability of steady states, and then discuss two different types of treatments: constant and periodic, comparing their effectiveness.

Discontinuous Galerkin methods on essentially arbitrarily shaped element meshes

Schedule: July 6 16:30-17:00 Room 445

Emmanouil Georgoulis

National Technical University of Athens / Heriot-Watt University, Greece

Abstract:

We extend the applicability of the popular interior penalty discontinuous Galerkin (dG) method for discretising advection diffusion reaction problems to meshes comprising extremely general, essentially arbitrarily shaped elements. In particular, our analysis allows for curved element shapes without the use of iso-parametric elemental maps. The feasibility of the method relies on the definition of a suitable discontinuity penalisation parameter, which turns out to be essentially independent of the particular element shape. A priori error bounds for the resulting method are given under very mild structural assumptions restricting the magnitude of the local curvature of element boundaries. Numerical experiments are also presented, indicating the practicality of the proposed approach. This work generalises our earlier work detailed in the monograph.

Cancer invasion and metastasis across phenotypic scales

Schedule: July 6 17:30-18:00 Room 445

Dimitrios Katsaounis

RWTH Aachen University, Germany

Abstract:

Cancer invasion and metastasis are inherently multiscale processes driven by complex interactions between cancer cells and the tumour microenvironment. A central mechanism underlying cancer heterogeneity is the epithelial-to-mesenchymal transition (EMT), through which proliferative epithelial-like cancer cells (ECCs), forming the bulk of solid tumours, progressively acquire migratory and invasive mesenchymal-like traits. Mesenchymal-like cancer cells (MCCs) can actively invade surrounding tissue and disseminate to distant organs via the vasculature. At secondary sites, they may undergo the reverse mesenchymal-to-epithelial transition (MET), enabling metastatic growth. Importantly, EMT is a continuous process that gives rise to intermediate hybrid phenotypes with increasing invasive potential. In this talk, we present a phenotype-dependent individual-based model together with its corresponding macroscopic formulation, incorporating continuous transitions along the epithelial-mesenchymal spectrum. This framework enables the study of the emergence and maintenance of phenotypic heterogeneity during tumour progression. Additionally, we investigate an individual-based model for MCC migration, focusing on the role of cell-cell adhesion in collective dynamics, informed by experimental data. In particular, we introduce a stochastic representation of N-cadherin-mediated adhesion, where bond lifetimes depend on the pulling force acting on the cells.

A Reduced Model of Aspiration Thrombectomy

Schedule: July 6 14:30-15:00 Room 445

Niklas Kolbe

RWTH Aachen University, Germany

Co-Author(s): Dimitrios Katsaounis, Agnese Lucchetti, Michael Neidlin

Abstract:

Aspiration thrombectomy has emerged as a critical intervention for ischemic stroke caused by large vessel occlusions, wherein a catheter is navigated to the occlusion site and suction is applied to restore cerebral blood flow. To facilitate efficient computational analysis of this procedure, we present a new one-dimensional fluid-structure interaction model that captures the essential hemodynamics while decreasing computational cost compared over three-dimensional simulations. The model includes detailed constitutive modeling of the catheter material properties and accounts for viscoelastic effects in the blood flow through a Voigt-Kelvin pressure formulation. To address the resulting coupled hyperbolic system, we construct problem-suited nodal solvers based on hyperbolic relaxation, which are integrated into a splitting approach to derive an efficient numerical scheme capable of simulating realistic therapy scenarios. We validate the proposed 1D model against experimental measurements from an in-vitro physical model and demonstrate good agreement with fully resolved 3D CFD simulations, establishing the reduced model's potential for clinical translation in thrombectomy planning.

Integrating mechanistic mathematical modelling and single-cell data to study cellular hierarchies in neural stem cells and glioblastoma

Schedule: July 6 13:30-14:00 Room 445

Anna Marciniak-Czochra

Institute for Mathematics, Heidelberg University, Germany

Abstract:

Understanding how heterogeneous cellular populations evolve is central to uncovering the mechanisms of tissue regeneration and cancer progression. In healthy neural stem cell systems and glioblastoma, cellular hierarchies and stem-like states govern long-term dynamics, adaptation, and functional plasticity. In this talk, I will present mathematical approaches that integrate mechanistic modelling with single-cell omics data to study the evolution of cellular states in space and time. Different mathematical frameworks will be discussed, including compartmental and structured population models, as well as their generalisation to the evolution of measures, which describe the dynamics of cell populations in the high-dimensional state spaces revealed by single-cell data. These approaches provide insight into transitions between stemness and differentiation and into how cellular hierarchies emerge and evolve in regeneration and cancer. The work highlights the potential of combining single-cell data with mechanistic mathematical modelling to uncover principles governing heterogeneous cellular systems.

CAR-T cell therapy for glioblastoma

Schedule: July 6 18:30-19:00 Room 445

Magdalena Szafranska-Leczycka

Doctoral School of Exact and Natural Sciences, University of Warsaw, Warsaw, Poland, Poland

Co-Author(s): Z. Szymańska, M. J. Piotrowska, M. Bodnar and U. Foryś

Abstract:

In this presentation, based on mathematical models incorporating tumor growth, delays in CAR-T cell proliferation, and the development of resistance mechanisms, we analyze treatment scenarios inspired by clinical trials targeting IL13Ralpha2, HER2, and EGFRvIII, as described in Migliorini et al. (2018). We focus on evaluating the effectiveness of different therapeutic protocols, including variations in dosing strategies and treatment scheduling. This approach allows us to compare how distinct treatment designs influence tumor dynamics and to identify which strategies lead to the most favorable outcomes. In addition, we perform sensitivity analysis to determine the key parameters that govern treatment success. This enables us to assess the relative importance of biological processes such as CAR-T expansion, tumor growth rate, and resistance development. The results provide deeper insights into the mechanisms underlying therapy efficacy and point to key factors that may limit or enhance the response to CAR-T cell treatment of glioblastoma multiforme.

Mathematical modelling of cancer invasion: Phenotypic transitioning provides insight into multifocal foci formation

Schedule: July 6 14:00-14:30 Room 445

Zuzanna Szymanska

ICM, University of Warsaw, Poland

Co-Author(s): Mirosław Lachowicz, Nikolaos Sfakianakis and Mark A.J. Chaplain

Abstract:

The transition from the epithelial to mesenchymal phenotype and its reverse (from mesenchymal to epithelial) are crucial processes necessary for the progression and spread of cancer. We investigate how phenotypic switching at the cancer cell level impacts the behaviour at the tissue level, specifically on the emergence of isolated foci of the invading solid tumour mass, leading to a multifocal tumour. To this end, we propose a new mathematical model of cancer invasion that includes the influence of cancer cell phenotype on the rate of invasion and metastasis. The implications of the model are explored through numerical simulations, revealing that the plasticity of tumour cell phenotypes appears crucial for disease progression and local invasive spread. The computational simulations show the progression of the invasive spread of primary cancer reminiscent of in vivo multifocal breast carcinomas, where multiple, synchronous neoplastic foci are frequently observed and are associated with a poorer patient prognosis.

Special Session 103 : The integrability and bifurcation theory of dynamical systems and its applications

Organizer(s): Dongmei Xiao , Valerij Romanovskij , Yilei Tang

Introduction: Bifurcation theory and integrability theory are essential tools for understanding complicate behaviors of dynamical systems, which play a crucial role in the study of nonlinear science. This session highlights recent advancements in these two theories and explore their applications in biology, ecology, engineering and life science. The session will provide a platform for theorists and applied mathematicians in this field to share their insights on fundamental principles governing the complex dynamic phenomena.

Elimination Methods for Computing Invariant Algebraic Surfaces of Dynamical Systems

Schedule: July 7 16:30-17:00 Room 638

Bo Huang

Beihang University, Peoples Rep of China

Co-Author(s): Changbo Chen, Bo Huang, Valery Romanovski and Linpeng Wang

Abstract:

Invariant algebraic surfaces are polynomial surfaces that remain fixed under the flow of a differential system, meaning solutions starting on the surface stay on the surface. They are crucial for understanding the global dynamics of a system, and their existence often indicates the presence of Darboux integrals, which can simplify the analysis of chaotic and nonchaotic behavior. In this talk, we propose a computational framework that combines Gröbner bases and triangular sets. This framework first utilizes Gröbner bases to compute elimination ideals and obtain parametric constraints for the existence of invariant algebraic surfaces, then employs triangular decomposition algorithms to derive explicit expressions, and finally performs reduction through variable substitution using the previously obtained constraints to yield concise expressions for invariant algebraic surfaces. The effectiveness of the proposed methods is validated through computations of invariant algebraic surfaces (curves) for the Belousov--Zhabotinsky reaction model and the Rayleigh--Liénard oscillation system.

First Integrals and Invariants of Systems of ODEs

Schedule: July 7 15:00-15:30 Room 638

Abdul Jarrah

American University of Sharjah, United Arab Emirates

Co-Author(s): Mateja Grasic and Valery Romanovski

Abstract:

In this talk, we study the relationship between monomial first integrals, polynomial invariants arising from certain group actions, and the Poincaré--Dulac normal forms of autonomous systems of ordinary differential equations with a diagonal linear part. Using tools from computational algebra, we develop algorithmic methods for identifying generators of the algebras of monomial and polynomial first integrals, including the general case where the eigenvalues of the linear part are algebraic complex numbers. The approach also provides a practical way to explore the structure of polynomial invariants and their connection to the Poincaré--Dulac normal forms of the underlying vector fields.

On the IFS which admits a specified attractor

Schedule: July 7 13:30-14:00 Room 638

Wenxia Li

East China Normal University, Peoples Rep of China

Co-Author(s): D.R Kong, W.X. Li, Z.Q.Wang, Y.Y. Yao, Y.X. Zhang

Abstract:

An iterated function system (IFS) is a finite collection of contractive maps $\{f_i(x) = \beta_i x + \gamma_i : i = 1, 2, \dots, n\}$ with $\beta_i, \gamma_i \in \mathbb{R}$ and $|\beta_i| < 1$

Support measures and complex dimensions in dynamics

Schedule: July 7 14:30-15:00 Room 638

Goran Radunovic

University of Zagreb, Croatia

Co-Author(s): Goran Radunović and Steffen Winter

Abstract:

The general Steiner formula of Hug, Last and Weil describes the tube volume of any closed set in $\mathbb{R}^d$, and the support measures arising from this formula encode its geometric properties. Recently, basic contents and support contents have been introduced as tools to extract fractal properties of a set from these measures. The original motivation was to extract the geometric meaning of the coefficients in fractal tube formulas that arise in the theory of complex dimensions by Lapidus, Radunovic, and Zubrinic. This is achieved by introducing appropriate zeta functions associated to each support measure, which turn out to be useful tools for computing basic contents and support contents. We will reflect on applications of these new functionals to analysis of orbits of dynamical systems. Based on joint work with Steffen Winter.

Rigidity of saddle loops

Schedule: July 7 18:30-19:00 Room 638

Maja Resman

University of Zagreb, Croatia

Co-Author(s): D. Panazzolo, L. Teyssier

Abstract:

We define an abstract complex saddle loop in $\mathbb{C}^2$ as a pair $(\mathcal{F}, R)$ of a hyperbolic normalized saddle foliation $\mathcal{F}$ with a corner Dulac map D and a regular map $R \in \text{Diff}(\mathbb{C}, 0)$. Up to an appropriate equivalence relation that corresponds to different determinations of complex Dulac and to transversal changes, the first return map is given by $F = RD$ on the universal cover of the standard quadratic domain. We show that such Poincaré maps are rigid, in the sense that their non-ramified formal conjugacy implies the analytic conjugacy (in $\text{Diff}(\mathbb{C}, 0)$, lifted to the universal cover).

Research on Center-Related Problems of Generalized Kukles Systems

Schedule: July 7 17:30-18:00 Room 638

Yilei Tang

Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

In this talk we investigate center-related problems for generalized Kukles systems. We derive sufficient and necessary conditions for the origin of such systems with $\mathbb{Z}_2$ -symmetry or weak $\mathbb{Z}_2$ -symmetry to be a center. Moreover, we provide examples to illustrate the center conditions using our theoretical results and give a negative answer to a conjecture proposed in the literature. Moreover, we investigate the problem of integrability for general generalized Kukles systems when they admit a center.

Long-time behavior for some reaction-diffusion systems

Schedule: July 7 17:00-17:30 Room 638

Shi-Liang Wu

xidian university, Peoples Rep of China

Abstract:

In this talk, we first review some existing results on the long-time behavior of bounded solutions to reaction-diffusion equations. We then present our recent works on the long-time dynamics of solutions to several classes of biological reaction-diffusion systems.

The stability and bifurcation of ecosystems within a defined energy landscape

Schedule: July 7 18:00-18:30 Room 638

Dongmei Xiao

Shanghai Jiao Tong University, Peoples Rep of China

Co-Author(s): Tianwei Gan, Dongmei Xiao and Chenwan Zhou

Abstract:

In this talk, we first assume that a defined energy landscape becomes the resource constraint in ecological community, then give three-dimensional Lotka-Volterra models within a defined energy landscape, and study bifurcations for a class of the three-dimensional Lotka-Volterra models as an example, discover the existence of strange bifurcations by using a conserved quantity as a bifurcation parameter, which reveals how resource constraints influence the coexistence of the species and their long-term dynamics.

Parametric normal forms and further simplification

Schedule: July 7 15:30-16:00 Room 638

Weinian Zhang

Sichuan University, Peoples Rep of China

Co-Author(s): Weinian Zhang

Abstract:

Given a family of vector fields parametrized by ξ in its linear part, one usually obtains its versal unfolding by the so-called two-step approach. It is also a common practice to suspend ξ and calculate normal forms of the extended system. In this work we reformulate normal forms on modules of homogeneous polynomials over the ring of all continuous functions of ξ and give a direct computation of versal unfolding. Our procedure enables us to determine coefficients of all terms of a certain degree in the normal form before we give a near-identity transformation of this degree. We can give all available near-identity transformations and choose an appropriate one to eliminate more terms of higher degree for a simpler normal form. We prove that the normal form reduced in our procedure is the simplest and unique. We illustrate our method with systems of linear centre and nilpotent linear parts separately.

Traveling wave trains and fronts in a reaction--diffusion model of seagrass meadows

Schedule: July 7 14:00-14:30 Room 638

Xiang Zhang

Shanghai Jiao Tong University, Peoples Rep of China

Co-Author(s): Qi Qiao and Baodong Zhang

Abstract:

In this talk we report our results on a model, posed by Moreno-Spiegelberg et al. [Proc. Natl. Acad. Sci. 2025], that incorporates positive feedback together with negative feedback mediated by an inhibitor, and successfully applied it to *Posidonia oceanica* meadows to explain the observed spatiotemporal phenomena. The original authors worked via numerical simulations and theoretical analysis and produced various spatiotemporal patterns, such as traveling pulses, wave trains, expanding rings, and spiral waves. Here our work rigorously establishes the existence of traveling pulses, traveling fronts, wave trains, as well as pulled and pushed fronts for this model. Our approach, based on geometric singular perturbation theory, allows us to construct traveling waves far from equilibrium, and can reveal more organized underlying structures. This provides a rigorous mathematical foundation for the wave phenomena, and contribute to a deeper understanding of the mechanisms generating complex spatiotemporal patterns in spatially extended ecological systems. This is a joint work with Qi Qiao and Baodong Zhang, which is based on our paper in J. London Math. Soc. (2) 2026; 113: e70428.

Special Session 105 : Dynamics of Many-Particle Systems and Mean-field Equations

Organizer(s): Hui Huang , Hicham Kouhkouh

Introduction: Many-particle systems and mean-field equations are nonlocal models that play a central role in describing complex interactions across physical, biological and social systems. In many settings, large ensembles of interacting agents can be effectively described by continuum equations derived through mean-field limits. This transition from discrete particle dynamics to nonlocal partial differential equations presents deep mathematical challenges, involving singular interactions, stochastic effects, and high-dimensional behavior. Recent progress has shed new light on the rigorous derivation of mean-field models, the qualitative properties of nonlocal PDEs, and the development of structure-preserving numerical methods. At the same time, emerging tools from optimal transport, variational analysis, and scientific machine learning offer new perspectives on classical problems, such as pattern formation, stability, and long-time asymptotics. This special session will bring together researchers working at the interface of many-particle dynamics, nonlocal models, and continuum limits, aiming to foster a deeper understanding of the analytical, probabilistic, and computational aspects of these systems.

Pair approximation for continuous-valued dynamics on networks

Schedule: July 7 9:30-10:00 Room 642

WEIQI CHU

University of Massachusetts Amherst, USA

Abstract:

Dynamics on networks arise in diverse contexts such as information spreading, disease transmission, epidemiology, opinion dynamics, and statistical physics. In these systems, agents (nodes) interact with their neighbors through network edges, and their states evolve in time depending on the states of their neighbors. The network structure, therefore, plays an essential role in shaping the overall dynamics. When networks are large or highly heterogeneous, direct computations become infeasible and mean-field approximations often fail to capture essential correlations. Pair approximation offers a powerful reduction framework by incorporating network heterogeneity through degree-based correlations, but most existing analyses focus on systems with discrete-valued states, where agents take values from a finite set. In this work, we extend the framework to continuous-valued dynamics. We introduce a family of degree-based density functions to characterize the state distributions of nodes with the same degree and derive the corresponding pair approximation for these density functions.

Data-driven Learning of Interaction Laws in Multispecies Particle Systems

Schedule: July 6 14:30-15:00 Room 642

Jinchao Feng

Great Bay University, Peoples Rep of China

Co-Author(s): Charles Kulick, Sui Tang

Abstract:

We develop a Gaussian process framework for learning interaction kernels in multi-species interacting particle systems from trajectory data. Such systems provide a canonical setting for multiscale modeling, where simple microscopic interaction rules generate complex macroscopic behaviors. We formulate the learning problem in a nonparametric Bayesian setting and establish rigorous statistical guarantees. Our analysis shows recoverability of the interaction kernels, provides quantitative error bounds, and proves statistical optimality of posterior estimators, thereby unifying and generalizing previous single-species theory. Numerical experiments confirm the theoretical predictions and demonstrate the effectiveness of the proposed approach, highlighting its advantages over existing kernel-based methods. This work contributes a complete statistical framework for data-driven inference of interaction laws in multi-species systems, advancing the broader multiscale modeling program of connecting microscopic particle dynamics with emergent macroscopic behavior.

Mass splitting in the generalized Euler equations: a new explanation via discretization

Schedule: July 7 9:00-9:30 Room 642

Gero Friesecke

Technical University of Munich (TUM), Germany

Abstract:

Arnold made the celebrated observation that solutions to the incompressible Euler equations of fluid dynamics correspond to geodesics in the group of volume-preserving diffeomorphisms. A nontrivial fact is that minimizers of the corresponding variational principle may not exist. Brenier introduced a relaxation which he showed to be well-posed. Physically this formulation allows mass splitting, i.e., a fluid particle can move from A to B via an ensemble of trajectories. Mathematically this formulation is an instance of multi-marginal optimal transport; for a simple introduction to this formulation see my recent textbook on optimal transport [1]. After reviewing the different formulations of the Euler equations, we - show that mass splitting still occurs after discretizing Brenier's relaxation either in time or in both space and time - provide a new argument for the mass splitting which is much simpler than previous analyses of the continuous case and reveals a transparent underlying mechanism. We close with a brief discussion from a modeling point of view: what is physically more correct, Euler (no mass splitting) or Brenier (mass splitting)? [1] G. Friesecke, Optimal Transport: a Comprehensive Introduction to Modeling, Analysis, Simulation, Applications, SIAM, 2025

Large-Corridor Pedestrian Flow and Non-Separable Mean-Field Games: A Stability Analysis

Schedule: July 6 17:00-17:30 Room 642

Mohamed Ghattassi

NYU Abu Dhabi, United Arab Emirates

Abstract:

We investigate the existence and stability of small perturbations of constant states of the generalized Hughes model for pedestrian flow in an infinitely large corridor. We show that constant flows are stable under a condition on the density. Our findings indicate that when the density is less than half of the maximum density, which is the Lasry-Lions monotonicity condition, we can control the perturbation and prove positive stability results for the nonlinear Generalized Hughes model.

Propagation of chaos for multi-species moderately interacting particle systems up to Newtonian singularity

Schedule: July 6 14:00-14:30 Room 642

Shuchen Guo

University of Oxford, England

Co-Author(s): Jose Carrillo and Alexandra Holzinger

Abstract:

We derive a class of multi-species aggregation-diffusion systems from stochastic interacting particle systems via relative entropy method with quantitative bounds. We show an algebraic L^1 -convergence result using moderately interacting particle systems approximating attractive/repulsive singular potentials up to Newtonian/Coulomb singularities without additional cut-off on the particle level. The first step is to make use of the relative entropy between the joint distribution of the particle system and an approximated limiting aggregation-diffusion system. A crucial argument in the proof is to show convergence in probability by a stopping time argument. The second step is to obtain a quantitative convergence rate to the limiting aggregation-diffusion system from the approximated PDE system. This is shown by evaluating a combination of relative entropy and L^2 -distance.

Optimal control of diffusive mean-field models for swarming particles on the sphere

Schedule: July 6 18:30-19:00 Room 642

Dohyun Kim

Sungkyunkwan University, Korea

Co-Author(s): Jinwook Jung

Abstract:

We study a mean-field optimal control problem for a consensus (high-dimensional Kuramoto-type) dynamics with diffusion on the unit sphere. The control acts through a prescribed drift field and an interaction gain, and the cost functional is given to track a given target density while penalizing the control effort. At the microscopic level, we formulate the corresponding controlled N -particle Liouville problem and establish the existence of optimal controls. For fixed controls, we obtain a quantitative stochastic mean-field limit showing that the one-particle marginal converges to the mean-field solution with the convergence rate $\mathcal{O}(1/\sqrt{N})$. Finally, we show that microscopic optimal controls approximate a mean-field optimal control: any weak limit of particle-level minimizers is optimal for the mean-field problem.

Analysis of an iterative scheme for computing the Kantorovich problem

Schedule: July 7 8:30-9:00 Room 642

Hicham Kouhkouh

University of Graz, Austria

Co-Author(s): Likhith Ganedi

Abstract:

In the study of multi-particle dynamics and mean-field equations, the Wasserstein distance plays a central role in quantifying the evolution of particle distributions. With Likhith Ganedi (University of Utah), we introduce a simple algorithm for the computation of the Wasserstein metric based on a gradient ascent flow for the Monge-Kantorovich dual formulation, and using a discrete approximation of the double c-transform. The method is computationally efficient and does not require entropic regularization, which can otherwise introduce approximation errors. In addition, we develop a framework for analyzing its global convergence by studying the discrete-to-continuous limit of the underlying dynamics. This approach yields convergence guarantees and highlights a connection with elliptic regularity.

Convergence Rates of Mean-Field Fluctuations in the 2D Viscous Vortex and Coulomb Models

Schedule: July 6 15:30-16:00 Room 642

Paul Nikolaev

TU Berlin, Germany

Co-Author(s): Alekos Cecchin

Abstract:

We investigate how fluctuations behave in large systems of interacting particles when the interaction is given by the Biot--Savart kernel, a key model from fluid dynamics. Our main result provides the first quantitative convergence rates for these fluctuations, and remarkably, the rates are optimal. The key idea is to compare the generators of the particle system and of the limiting fluctuation process in an infinite-dimensional setting. This comparison allows us to derive a sharp error bound for the fluctuations. Beyond the Biot--Savart case, the method is versatile and can also be applied to other singular interactions, such as the repulsive Coulomb kernel or general interactions of mean-field type.

On the Diffusive-Mean Field limit of Kinetic Interacting Particle Systems

Schedule: July 6 13:30-14:00 Room 642

Grigorios A Pavliotis

Imperial College London, England

Co-Author(s): R. Gastaldello, G. Stoltz, and U. Vaes

Abstract:

We study the joint diffusive-mean field limit for a system of weakly interacting kinetic Langevin dynamics. We show that, in the absence of phase transitions, the two limits commute, and we calculate the covariance matrix of the limiting Brownian motion using the Green-Kubo/Kipnis-Varadhan formula. However, at low temperatures, and in the presence of phase transitions, the two limits may not commute. We demonstrate our findings by providing a detailed analysis of the diffusive-mean field limit for the $O(2)$ model in a magnetic field. Our analysis is based on the systematic use of recently developed hypocoercivity techniques, together with an appropriate linearization of the mean field McKean-Vlasov-Fokker-Planck PDE.

New results on the critical Keller-Segel system

Schedule: July 6 16:30-17:00 Room 642

Filippo Santambrogio

Institut Camille Jordan, France

Co-Author(s): Charles Elbar, Alejandro Fernandez-Jimenez

Abstract:

The talk will be concerned with aggregation diffusion equations and in particular with the well-known Keller-Segel model for chemotaxis, where a particle population is subject to diffusion and to advection in the direction of the gradient of the concentration of a substance produced by the particles themselves. Such a concentration is defined at each point in terms of a non-local integral involving the whole distribution of particles. I will briefly recall the main facts about the Keller-Segel system with particular attention to the critical cases, in terms of diffusion exponent and mass and depending on the dimension, and then present some recent results obtained in collaboration with Elbar and Fernandez-Jimenez. In our recent work we obtained a new estimate on the Laplacian of the pressure associated with the solution, which allows one to obtain or recover global existence results, regularity and regularization, and information of the asymptotic behavior and decay.

Particle-Based Stochastic Reaction-Diffusion Models: Mean field limits and fluctuation corrections.

Schedule: July 6 15:00-15:30 Room 642

Konstantinos Spiliopoulos

Boston University, USA

Abstract:

Particle-based stochastic reaction-diffusion (PBSRD) models are a popular approach for studying biological systems involving both noise in the reaction process and diffusive transport. In this work we derive coarse-grained deterministic partial integro-differential equation (PIDE) models that provide a mean field approximation to the volume reactivity PBSRD model, a model commonly used for studying cellular processes. We formulate a weak measure-valued stochastic process (MVSP) representation for the volume reactivity PBSRD model, demonstrating for a simplified but representative system that it is consistent with the commonly used Doi Fock Space representation of the corresponding forward equation. We then prove, (a): the convergence of the general volume reactivity model MVSP to the mean field PIDEs in the large-population (i.e. thermodynamic) limit, and (b): the next order fluctuation correction to the mean field limit, which satisfies systems of stochastic PIDEs with Gaussian noise. Numerical examples are presented to illustrate how such approximations can enable the accurate estimation of higher order statistics of the underlying PBSRD model.

MEAN-FIELD CONTROL FOR DIFFUSION AGGREGATION EQUATION WITH COULOMB INTERACTION

Schedule: July 6 17:30-18:00 Room 642

Yucheng Wang

Shanghai University, Peoples Rep of China

Co-Author(s): Li Chen, Zhao Wang

Abstract:

The mean-field control problem for a multidimensional diffusion--aggregation system with Coulomb interactions (the so-called parabolic elliptic Keller--Segel system) is considered. The existence of optimal control is proven through the Γ convergence of the corresponding control problem of the interacting particle system. There are three building blocks in the overall argument. First, for the optimal control problem at the particle level, instead of using the classical method for stochastic systems, we directly study the control problem of high-dimensional parabolic equations, specifically the Liouville equation. Second, we obtain strong propagation of chaos results for the interacting particle system by combining the convergence in probability and relative entropy methods. Owing to this strong mean-field limit result, we avoid imposing compact support requirements for control functions, which have often been used in the literature. Third, because of the strong aggregation effect, additional difficulties arise from the control function in obtaining the well-posedness theory of the diffusion--aggregation equation, making known methods inapplicable. Instead, we use a combination of local existence results and bootstrap arguments to obtain the global solution in the subcritical regime.

Optimal Control for Kuramoto Model: from Many-Particle Liouville Equation to Diffusive Mean-Field Problem

Schedule: July 6 18:00-18:30 Room 642

Valeriia Zhidkova

University of Mannheim, Germany

Co-Author(s): Li Chen, Yucheng Wang

Abstract:

We investigate the mean-field optimal control problem of a swarm of Kuramoto oscillators. Using the notion of wrapped distribution, we explain the connection between the stochastic particle system and the mean-field PDE on the periodic domain. In the limit of an infinite number of oscillators, the collective dynamics of their density is described by a diffusive mean-field model in the form of a nonlocal PDE, where the nonlocal term arises from the synchronization mechanism. We prove that the macroscopic optimal control problem admits a solution by using Γ -convergence strategy of the cost functional corresponding to the Liouville equation on the particle level.

Special Session 106 : Nonlocal and Local Interactions in Population Dynamics: Mathematical Analysis and Numerical Approaches.

Organizer(s): Silvia Sastre Gómez , Cristian Morales Rodrigo , Juan Vicente Gutiérrez Santacreu

Introduction: Traditional local models in population dynamics are insufficient to capture the full scope of biological realities, as species often respond to cues and interactions over extended spatial ranges. This session emphasizes the importance of incorporating nonlocal terms into population models, reflecting behaviors influenced by external information, resources, or sensory perceptions such as olfactory or visual cues. The inclusion of nonlocal interactions introduces complex mathematical challenges but enriches the dynamical properties of these systems. We will explore recent advances in the analysis of partial differential equations (PDEs) that describe such models, focusing on the existence, uniqueness, regularity, and asymptotic behavior of solutions. Additionally, the session will present numerical methods designed to accurately approximate these equations, emphasizing stability and fidelity to biological phenomena. A particular focus will be on models involving transport terms that simulate chemical attraction or repulsion, further aligning mathematical models with biological processes. By bringing mathematical rigor with biological relevance, this session aims to contribute to the development of robust analytical and computational tools for these complex systems.

Nonlocal diffusion equations in measure spaces

Schedule: July 8 17:30-18:00 Room 427

Ana Casado Sanchez

Universidad de Sevilla, Spain

Co-Author(s): M. Molina Becerra, A. Suarez

Abstract:

We study the existence of nonnegative and nontrivial solutions to a semilinear elliptic problem in which the classical diffusion term is replaced by an integral operator defined on a measure space. Problems of this type naturally arise in population dynamics, where the solution represents the density of individuals within a given domain. In particular, we establish existence and nonexistence results depending on the sign of the principal spectral value. Within this framework, we obtain a partition of the domain into subsets on which the problem can be solved independently. On each of these subsets, the strong maximum principle holds, which allows to find strictly positive solutions. We also present numerical simulations illustrating the theoretical results. These examples show how different choices of measures can model various situations, including random walk processes associated with Markov chains and scenarios where continuous measures of different dimensions coexist within the same domain.

Modeling the viscoelastic behavior of the skin using homogenization theory

Schedule: July 8 9:00-9:30 Room 427

Juan Casado-Díaz

University of Sevilla, Spain

Abstract:

In the mathematical modeling of the mechanical behavior of the skin, it is common to assume that it has a viscoelastic behavior. That is, an elastic material with memory. Some models consider an instantaneous memory term while other deal with a long-range memory term. Our aim is to deduce such behavior via homogenization theory from a simple model where the cells are represented by fluid-filled sacs immersed in an elastic medium that represents what in Biology is known as the extracellular matrix. Assuming that the behavior of the fluid is given by the Stokes system and the one of the solid part by the linear elasticity system we obtain a macrostructure model where the skin behaves as a viscoelastic material with a long-range memory term which decreases exponentially to zero. We also show that the model has some good properties permitting to prove the existence and uniqueness of solution and the energy conservation. These properties can be characterized in terms of the Laplace transform of the corresponding operator and can be used for more general models that are not necessarily the one obtained in the work.

Challenging the Blow-up Threshold: Numerical Analysis of the Keller-Segel-Navier-Stokes System

Schedule: July 8 16:30-17:00 Room 427

Juan Vicente Gutiérrez-Santacreu

Universidad de Sevilla, Spain

Abstract:

This talk investigates the stability and singularity formation (blow-up) in the Keller-Segel-Navier-Stokes system, which models chemotaxis in fluid environments. While existing theory establishes a mass threshold of 2π for global existence, its optimality remains unresolved. We introduce a stabilized finite element method with shock-capturing to explore numerical blow-up scenarios, ensuring the preservation of key physical properties such as positivity and mass conservation. Our results indicate that the 2π threshold may not be sharp; we conjecture that the true critical value could be 4π , as in the fluid-free Keller-Segel system. Additionally, numerical experiments reveal that stronger fluid flows can suppress singularity formation, effectively preventing chemotactic collapse.

The phenomenon of quenching in a system with non-local diffusion

Schedule: July 8 17:00-17:30 Room 427

Sergio Junquera

Universidad Complutense de Madrid, Spain

Co-Author(s): Jose M. Arrieta, Raul Ferreira

Abstract:

Diffusion models appear in multiple sciences such as biology, physics or even economics. They come up naturally as a broad class of natural processes and, in some cases, such as the propagation of a pathogen, the particles may jump long distances in each instant of time thanks to various means of transport. We call this non-local diffusion, and it is modeled by operators such as those of the type $J * u - u$, where the kernel J is a density function of the probability of jumps happening. The phenomenon of quenching in a dynamical system consists of the explosion of the velocity of the solution while the solution itself remains bounded. This phenomenon appears naturally in physical models such as the nonlinear heat conduction in solid hydrogen or the Arrhenius Law in combustion theory. The aim of this talk is to speak about our study of a system of equations with weakly coupled singular absorption terms and a non-local diffusion operator and the quenching phenomena that arises. We will show our results about the system, which tackle the appearance of stationary solutions, the quenching rates of both components and the possibility of both components presenting quenching at the same time.

Non-local behavior of strongly heterogeneous thin elastic materials

Schedule: July 8 14:00-14:30 Room 427

Manuel Luna-Laynez

Universidad de Sevilla, Spain

Co-Author(s): Juan Casado-Diaz, Carmen Calvo-Jurado

Abstract:

In some applications, local models may be insufficient to describe important characteristics of the phenomena under study. This may be the case when magnitudes appear in the model that can vary considerably from one area to another in close proximity, which can produce memory effects. In this work, we consider the evolutionary linear elasticity system in a thin domain, with thickness of order ε , and with mass density and elasticity tensor that can vary arbitrarily with ε . Using asymptotic techniques for thin domains and homogenization theory, we prove that when ε tends to zero, a new model is obtained in the limit that can include non-local terms in time. This model has applications in biomechanics, in the study of the elastic properties of organs and tissues.

On the regularity of optimal potentials for some elliptic control problems

Schedule: July 8 15:30-16:00 Room 427

Faustino Maestre

Universidad de Sevilla, Spain

Co-Author(s): Giuseppe Buttazzo, Juan Casado-Diaz

Abstract:

In this work, we study an optimal control problem governed by an elliptic partial differential equation of Schrodinger type where the control is a potential. We consider a cost functional of integral type which involves the solution of the state equation and a penalization term of the control variable. It can represent biological models to control the size of a total population or the optimal location of resources. We focus on the regularity of optimal solutions, that no better than BV one can be expected. We present different examples, where bang-bang behavior of optimal solutions occur and we show some numerical simulations.

Lotka-Volterra models with Nonlocal Coefficient Diffusion

Schedule: July 8 15:00-15:30 Room 427

Cristian Morales Rodrigo

Universidad de Sevilla, Spain

Abstract:

This talk is devoted to classical Lotka-Volterra models incorporating nonlocal diffusion; specifically, models where the diffusion coefficient depends nonlinearly on the total mass population. The inclusion of these nonlocal terms introduces greater technical difficulties compared to their local counterparts. Furthermore, we demonstrate how nonlocal diffusivity alters the structure of coexistence states with respect to the classical Lotka-Volterra systems.

Hydrodynamic limit of the kinetic Cucker-Smale model toward the incompressible Euler-alignment model

Schedule: July 8 9:30-10:00 Room 427

David Poyato

University of Granada, Spain

Co-Author(s): Francesco Fanelli and Gabriele Sbaiz

Abstract:

We present the rigorous hydrodynamic limit of the kinetic Cucker-Smale model in the d -dimensional torus including collisions described by the nonlinear Fokker-Planck operator. We focus on the regime where collisions have large frequency and also large mean thermal velocity. The limiting system is characterized by the incompressible Euler-alignment model with weakly singular influence function. Contrarily to previous literature, where all the resulting hydrodynamic limits led to (both pressureless and pressured) compressible versions of the Euler-alignment system, we obtain incompressible alignment models for the first time in the literature. We develop a holistic method combining techniques from hydrodynamic limits for kinetic systems based on relative entropy methods for the macroscopic quantities, together with tools from incompressible limits of Euler-type systems via compensated compactness arguments. We also discuss some well-posedness results of the involved systems, with particular emphasis on the new target system.

Convergence of principal eigenvalue for equation with local and nonlocal terms

Schedule: July 8 13:30-14:00 Room 427

Silvia Sastre Gómez

Universidad de Sevilla, Spain

Co-Author(s): Willian Cintra and Antonio Suárez Fernández

Abstract:

We consider an eigenvalue problem for a local-nonlocal equation that includes the Laplace operator and a nonlocal operator with a regular kernel. A comprehensive analysis of the principal eigenvalue is performed, and several monotonicity properties are presented with respect to the domain and the kernel. In particular, we study the principal eigenvalue of the equation where the Laplace operator term is multiplied by ϵ . Finally, we analyze the convergence of the principal eigenvalue as ϵ goes to zero and as ϵ goes to infinity.

SPATIAL ECOLOGY MODELS WITH INERTIA AND TIME-DEPENDENT PARAMETERS: A NONAUTONOMOUS HYPERBOLIC CAUCHY PROBLEM APPROACH

Schedule: July 8 14:30-15:00 Room 427

Paulo Nicanor Seminario Huertas

Polytechnic University of Madrid, Spain

Abstract:

In this talk, we will review the main results concerning hyperbolic Cauchy problems in which the family of generators associated with the system is time-dependent. In particular, we will discuss the uniqueness of weak solutions and their relationship with mild and classical solutions. As a concrete application motivated by pattern formation in semi-arid ecosystems, we will address a non-homogeneous ecological model coupling non-local biomass dispersion (higher-order spatial operators) with a Cattaneo-type delayed resource flow. We will highlight how our theoretical framework ensures the well-posedness of such strongly coupled systems even when all ecological and physical parameters vary continuously with time, reflecting seasonal forcing and climatic variations.

Spatiotemporal pattern formation in nonlocal aggregation-diffusion model driven by asymmetric spatial cognitive map

Schedule: July 8 8:30-9:00 Room 427

Junping Shi

College of William & Mary, USA

Co-Author(s): Di Liu, Junping Shi, Hao Wang

Abstract:

Nonlocal aggregation-diffusion models, when coupled with a spatial map, can capture cognitive and memory-based influences on animal movement and population-level patterns. A reaction-diffusion-aggregation system coupled with a separate dynamically updating map is proposed to describe the animal population movement. We will show that when an asymmetric cognitive map influences instantaneously, a rotating movement pattern emerges.

Special Session 107 : Recent advances in regularity theory for local and nonlocal elliptic and parabolic equations

Organizer(s): Sun-Sig Byun , Jehan Oh , Yeonghun Youn

Introduction: There has been significant progress in the study of local and nonlocal problems in elliptic and parabolic equations. In the local setting, refined techniques have deepened classical regularity theory, while the nonlocal framework has led to sharp results for fractional and integro-differential models. This session will highlight recent advances in both directions, as well as in mixed local–nonlocal problems, emphasizing novel analytical methods and regularity phenomena that play a central role in modern partial differential equations and their applications.

μ -ellipticity and nonautonomous integrals

Schedule: July 6 18:30-19:00 Room 738

Filomena De Filippis

University of Salzburg, Austria

Abstract:

μ -ellipticity describes certain degenerate forms of ellipticity typical of convex integrals at linear or nearly linear growth, such as the area integral or the iterated logarithmic model. The regularity of solutions to autonomous or totally differentiable problems is classical after Bombieri, De Giorgi and Miranda, Ladyzhenskaya and Ural'tseva and Frehse and Seregin. The anisotropic case is a later achievement of Bildhauer, Fuchs and Mingione, Beck and Schmidt and Gmeineder and Kristensen. However, all the approaches developed so far break down in presence of nondifferentiable ingredients. In particular, Schauder theory for certain significant anisotropic, nonautonomous functionals with Holder continuous coefficients was only recently obtained by C. De Filippis and Mingione. We will see the validity of Schauder theory for anisotropic problems whose growth is arbitrarily close to linear within the maximal nonuniformity range, and discuss sharp results and insights on more general nonautonomous area type integrals. We also present an intrinsic approach to Schauder theory for general nonautonomous functionals at nearly linear growth, covering the most relevant model examples in the literature. From recent joint work with Cristiana De Filippis (Parma), Mirco Piccinini (Polimi) and Peter Hasto (Helsinki).

Game-theoretic approaches to partial differential equations and related problems

Schedule: July 6 Room 738

Jeongmin Han

Soongsil University, Korea

Abstract:

Probabilistic approaches have long been one of the powerful tools in the study of PDEs. It not only offers an alternative perspective for understanding these equations but has also contributed to new mathematical developments in the field. A classical example is the use of random walks in the study of the Laplace equation, where the mean value property of harmonic functions serves as the key connection. Similar ideas can be applied to a broader class of equations. In the nonlinear setting, the so-called tug-of-war game provides a representative example. This stochastic game can be interpreted as a discretized scheme for the normalized p -Laplace operator. In this talk, I will mainly discuss research on p -Laplace type PDEs and related problems approached through tug-of-war. Recently, such game-theoretic approaches have also been actively employed in exploring other PDEs and neighboring areas, and I will touch upon some of these developments as well.

Existence results for nonlinear diffusion equations with drifts in divergence form

Schedule: July 6 18:00-18:30 Room 738

Sukjung Hwang

Chungbuk National University, Korea

Abstract:

In this presentation, we discuss recent existence results for nonlinear diffusion equations with drift terms in divergence form. These results are broadly applicable to a variety of reaction diffusion models, including Keller Segel models. We emphasize the identification of functional spaces for the drift term, guided by the diffusion nonlinearity and the regularity of the initial data.

Degenerate Nonlinear Partial Differential Equations in Curvature Flows

Schedule: July 6 16:30-17:00 Room 738

Ki-Ahm Lee

Seoul National University, Korea

Abstract:

This talk studies degenerate nonlinear partial differential equations arising in curvature flows with noncompact graphical initial hypersurfaces. The evolving hypersurface remains graphical and develops infinite height along the boundary of its support, leading naturally to a free boundary formulation. We establish uniform a priori estimates up to the infinite-height boundary despite the degeneracy of the equation, and analyze the evolution of the support and its free boundary. Geometric quantities preserved under the flow are also examined. Finally, we discuss cigar-type traveling wave solutions with flat regions to address Hamilton's problem on the existence of such flows.

Liouville-type theorems for nonlocal Lane--Emden inequalities via test function methods

Schedule: July 6 17:00-17:30 Room 738

Taehun Lee

Konkuk University, Korea

Co-Author(s): Takwon Kim

Abstract:

We establish Liouville-type theorems for nonnegative weak supersolutions of nonlocal Lane--Emden equations $L_K u = u^q$ in $\mathbb{R}^n$. For linear integro-differential operators of order $2s$, $s \in (0, 1)$, we prove that $u \equiv 0$ when $1 < q \leq n/(n - 2s)$, via a test function method combined with a dyadic decomposition of the nonlocal tail. We then extend the analysis to quasilinear operators of p -Laplacian type associated with general kernels satisfying mild structural conditions, where a singular test function $u^{-\alpha} \varphi$ yields the corresponding nonexistence result. The arguments are elementary, relying only on the weak formulation rather than the maximum principle, fundamental solutions, or extension methods, and are motivated by blow-up analysis in regularity theory.

Sobolev flow and doubly nonlinear parabolic type equations

Schedule: July 6 17:30-18:00 Room 738

Masashi Misawa

Kumamoto university, Japan

Abstract:

In this talk we shall study the gradient flow associated with the Sobolev inequality, called the p -Sobolev flow, which is described as a doubly nonlinear degenerate and singular parabolic equation. In the case $p=2$ the p -Sobolev flow is related to the so-called Yamabe flow in differential geometry. We consider Cauchy-Dirichlet problem for the p -Sobolev flow, and we show a boundedness, a positivity, a regularity of the solution and the asymptotic behavior at infinite-time of the p -Sobolev flow. For the proof we study a local boundedness, the so-called positivity-expansion being valid for doubly nonlinear parabolic equations. Our global existence of the p -Sobolev flow is based on the scaling transformation intrinsic to the doubly nonlinear parabolic equation and this approach also eventually leads to an application to the finite-time extinction-behavior for the so-called fast diffusive doubly nonlinear parabolic equation. This is partially based on a collaborative work with Tuomo Kuusi in University of Helsinki, Finland and Kenta Nakamura in Kumamoto University. References: T. Kuusi, M. Misawa, K. Nakamura: J. Geom. Anal. 30 no.2 (2020); J. Differ. Eq. 279 (2021); M. Misawa, K. Nakamura: Adv. Calc. Var. (2021); J. Geom. Anal. 33 no.1: 33 (2023); M. Misawa, K. Nakamura, Md Abu Hanif Sarkar: Nonlinear Differ. Eqn. Appl. 30 no.3: 43 (2023); M. Misawa: Calc. Var. 62 (2023), no. 9: 265; M. Misawa, Y. Yamaura: Math. Annalen (2025); T. Kuusi, M. Misawa, K. Nakamura: submitted

Calder\`{o}n-Zygmund estimates for (s, p) -Poisson type equations

Schedule: July 6 15:30-16:00 Room 738

Kristian Moring

Paris Lodron University of Salzburg, Austria

Co-Author(s): Verena Boegelein, Frank Duzaar and Naian Liao

Abstract:

We discuss gradient estimates of Calder\`{o}n-Zygmund type for local weak solutions to fractional p -Poisson type equations of order s . In the range $p > 1$ and $s \in (\frac{p-1}{p}, 1)$, these estimates lead to optimal integrability of the weak gradient in terms of the integrability of the right-hand side.

Conormal Derivative Problems for Quasilinear Elliptic Equations with Morrey Data

Schedule: July 6 13:30-14:00 Room 738

Dian K Palagachev

Politecnico di Bari, Italy

Abstract:

We will discuss regularity issues regarding the weak solutions to non-homogeneous conormal derivative problem for quasilinear divergence form elliptic equations modeled on the m -Laplacian operator. The nonlinear terms are given by Carathéodory functions and satisfy controlled growth structure conditions with respect to the solution and its gradient, while their x -behaviour is controlled in terms of suitable Morrey spaces. Global boundedness up to the boundary will be shown for the weak solutions of such equations, generalizing this way the classical L^p -result of Ladyzhenskaya and Ural'tseva to the framework of the Morrey scales.

Regularity theory for parabolic double phase problems

Schedule: July 6 14:30-15:00 Room 738

Abhrojyoti Sen

Goethe University Frankfurt, Germany

Abstract:

In this talk, we discuss recent regularity results for parabolic double-phase equations and systems, focusing on Lipschitz regularity in the presence of gradient nonlinearities. Our approach is based on the celebrated Ishii-Lions method for viscosity solutions. We show that when the modulating coefficient is spatially Lipschitz and its zero set satisfies a mild and natural control condition, then bounded weak solutions to parabolic double-phase equations with gradient nonlinearity are locally Lipschitz continuous in space and $1/2$ Hölder continuous in time. Furthermore, we also discuss the higher integrability result for parabolic double phase systems having two modulating coefficients.

Generalized Structural Conditions and Gradient Regularity for Double Phase Problems

Schedule: July 6 15:00-15:30 Room 738

Pilsoo Shin

Kyonggi University, Korea

Co-Author(s): Yeonghun Youn

Abstract:

In this talk, I introduce a generalized structural condition for the double phase problem. The main operator is expressed as the diagonal component of a suitable vector field $G(x, y, z)$ involving two spatial variables, where x is the variable modulating the growth and y is the variable that allows some additional irregularity on the main operator. Under this generalized structure, we show that by assuming an appropriate regularity assumption on the y variable, one can obtain certain regularity of the gradient of solutions.

Approximation of the Solutions to Quasilinear Parabolic Problems with Perturbed Coefficients

Schedule: July 6 14:00-14:30 Room 738

Lyoubomira Softova

Salerno University, Italy

Co-Author(s): Rosamaria Rescigno

Abstract:

We consider the Cauchy-Dirichlet problem for second order quasilinear operators of parabolic type in non-divergence form. The data are Carathéodory functions, and the principal part is of VMO_x -type with respect to the variables (x, t) . Assuming the existence of a strong solution u_0 , we apply the Implicit Function Theorem in a neighbourhood of this solution to show that small bounded perturbations of the data lead to small perturbations of the solution u_0 itself. Furthermore, we employ the Newton iteration procedure to construct an approximating sequence that converges to u_0 in the corresponding Sobolev space.

Special Session 108 : Regularity in local versus nonlocal problems

Organizer(s): Antonio Iannizzotto , Eurica Henriques , Simone Ciani

Introduction: As the interest toward both stationary and evolutive partial differential equations involving anisotropic, nonlinear, and nonlocal diffusion operators constantly grows, establishing regularity properties of the solutions to such equations remains one of the most challenging issues. In this special session, we aim at providing a resume of the state of the art and proposing new directions of research, with a special focus on the comparison between local and nonlocal theories. The speakers' list includes both well-established experts and young researchers, aiming at creating an occasion for fruitful discussions.

Interior Gradient Estimates for Nonhomogeneous Parabolic p -Laplace Systems

Schedule: July 10 10:30-11:00 Room 430

Pedra Andrade

Paris Lodron University of Salzburg, Austria

Co-Author(s): Verena Boegelein, Frank Duzaar and Kristian Moring

Abstract:

In this talk, I will discuss gradient estimates for weak solutions to nonhomogeneous parabolic p -Laplacian systems with a right-hand side in non-divergence form. Under suitable regularity conditions on the coefficients, we obtain improved integrability properties beyond those currently known in the literature. Our approach combines classical techniques, including comparison estimates and stopping-time arguments, to derive Calderon-Zygmund-type estimates.

Schauder estimates for parabolic p -Laplace systems

Schedule: July 9 17:30-18:00 Room 430

Verena Boegelein

University of Salzburg, Austria

Co-Author(s): Frank Duzaar, Ugo Gianazza, Naian Liao, Christoph Scheven

Abstract:

In this talk, we consider parabolic systems of p -Laplace type
$$\partial_t u - \operatorname{Div} (a(x,t) |\nabla u|^{\mu^2 + |Du|^{\frac{p-2}{2}} Du}) = 0 \quad \text{in } ET, \quad \text{where } p > 1, \mu \in [0, 1], \text{ and the coefficient } a \in L^\infty(ET) \text{ is bounded below by a positive constant and Hölder continuous with respect to the spatial variable } x.$$
 Via Schauder estimates we establish local Hölder continuity of the spatial gradient of bounded weak solutions. As an application, we derive Hölder estimates for the gradient of weak solutions to a doubly nonlinear parabolic equation in the supercritical fast diffusion regime. In particular, we obtain quantitative bounds for the spatial gradient and its Hölder continuity. This is joint work with F. Duzaar, U. Gianazza, N. Liao, and C. Scheven.

Holder regularity for a class of doubly non linear PDEs

Schedule: July 10 14:30-15:00 Room 430

Filippo Maria Cassanella

Università degli studi di Cagliari, Italy

Co-Author(s): Filippo Maria Cassanella

Abstract:

We prove local Hölder continuity for non negative, locally bounded, local weak solutions for the class of doubly nonlinear parabolic equations $\partial_t(u^q) + \operatorname{Div}(|Du|^{p-2} Du) = 0$ with $p > 2$ and $p - 1 > q > 0$. The novelty of the proof of such result is given by the use of an expansion of positivity argument, combined with the study of an alternative (related to DeGiorgi-type lemmas) and an exponential shift which allows us to deal with the intrinsic geometry associated to the problem.

Manifold-valued minimizers of double phase functionals: partial regularity and Lavrentiev gap

Schedule: July 10 14:00-14:30 Room 430

Filomena De Filippis

University of Salzburg, Austria

Abstract:

Two classical research topics in the calculus of variations are the study of regularity results for minimizers, with values in a manifold, of functionals with p -growth, whose foundations date back to the works of Eells & Sampson, Schoen & Uhlenbeck, Fuchs, Hardt & Lin and Luckhaus, and the density of smooth maps between compact manifolds in Sobolev spaces, characterized by Bethuel, Hang & Lin, and Hajlasz in terms of the topological properties of the target. In this talk we extend these themes to the nonuniformly elliptic setting of functionals with (p, q) -growth, with particular emphasis on double phase energies. We show that vector-valued minimizers subject to certain manifold constraints enjoy partial regularity of the gradient, that is, regularity of the solutions outside a negligible closed subset. We further investigate necessary and sufficient conditions for the density of smooth maps between suitable compact manifolds in nonhomogeneous spaces characterized by the finiteness of anisotropic energies such as those of double phase type. From joint works with C. A. Antonini, A. Nastasi, and C. Pacchiano Camacho.

Non-Diagonal Quasilinear Degenerate Elliptic Systems: Existence and Regularity

Schedule: July 10 9:30-10:00 Room 430

Patrizia Di Gironimo

Dipartimento di Matematica, Università di Salerno, Italy

Abstract:

In this talk, we discuss non-diagonal vectorial quasilinear degenerate elliptic systems defined on a bounded open set $\Omega \subset \mathbb{R}^n$, with $n > 2$, of the form
$$\begin{cases} -\operatorname{div} (a(x,u(x))Du(x)) = f(x), & x \in \Omega \\ u = 0, & x \in \partial\Omega \end{cases}$$
 where $u, f : \Omega \rightarrow \mathbb{R}^N$ and $a : \Omega \times \mathbb{R}^N \rightarrow \mathbb{R}^{N^2 n^2}$ is a bounded Carathéodory function. Unlike the scalar case, in the vectorial setting ($N \geq 2$) one cannot generally expect boundedness or high integrability of solutions, even for regular data. We will show how, by imposing conditions on the support of the off-diagonal coefficients, it is possible to guarantee existence of solutions whose regularity depends on the datum f . In particular, we will analyze the case where f belongs to an appropriate Marcinkiewicz space, highlighting regularity properties for the systems under consideration.

Regularity theory for sub-critical p -parabolic systems with measurable coefficients

Schedule: July 9 18:00-18:30 Room 430

Frank Duzaar

University of Salzburg, Austria

Co-Author(s): Verena Boegelein, Ugo Gioanazza, Naian Liao

Abstract:

A quantitative regularity theory is developed for weak solutions to the parabolic system

$$\partial_t u - \operatorname{div} A(x, t, Du) = 0 \quad \text{in } E_T \subset \mathbb{R}^N \times \mathbb{R},$$

which features the p -Laplacian with measurable coefficients. We focus on the sub-critical range $1 \leq p < \frac{N(2-p)}{p}$, we derive sharp, scale-invariant L^∞ -estimates. Higher integrability of the gradient: $|Du|$ self-improves from L^p_{loc} to $L^{p(1+\varepsilon)}_{\text{loc}}$ for some $\varepsilon > 0$ depending only on the data. The same results still hold given proper source terms.

Regularity Results for Weak Solutions of Singular Parabolic-Elliptic Chemotaxis Models with a Source Term

Schedule: July 10 12:00-12:30 Room 430

Fatma Gamze DUZGUN

Cagliari University, Italy

Abstract:

We study a quasilinear parabolic-elliptic chemotaxis system featuring singular porous medium-type diffusion, a nonlinear chemotactic sensitivity, and a source term that depends on both the cell density and its gradient. By applying the De Giorgi-DiBenedetto method, we demonstrate that the bounded solutions exhibit Holder continuity.

Towards local regularity for signed solutions to doubly nonlinear parabolic equations involving nonlocal operators

Schedule: July 10 15:00-15:30 Room 430

Simona Fornaro

University of Pavia, Italy

Co-Author(s): Eurica Henriques

Abstract:

In this talk I will present some preliminary results in order to study the local continuity of signed weak solutions to a class of parabolic doubly non linear equations involving a non local operator of p -Laplacian type

$$\partial_t(|u|^{q-1}u) + Lu = 0$$

where $q > 0$ and

$$Lu(x, t) = \text{P. V.} \int_{\mathbb{R}^N} K(x, y, t) |u(x, t) - u(y, t)|^{p-2} (u(x, t) - u(y, t)) dy,$$

with $p > 1$, $K : \mathbb{R}^N \times \mathbb{R}^N \times (0, T] \rightarrow [0, +\infty)$ measurable kernel, such that

$$\frac{C_0}{|x - y|^{N+sp}} \leq K(x, y, t) = K(y, x, t) \leq \frac{C_1}{|x - y|^{N+sp}} \quad \text{for a.a. } x, y \in \mathbb{R}^N$$

for some positive constants C_0, C_1 and $s \in (0, 1)$. The final aim consists in proving the Hölder estimate under a minimal tail condition, in the same spirit as in [1]. The approach is structural and relies on the so-called intrinsic geometry. Moreover it is quite general and we believe that it is possible to obtain a general modulus of continuity. [1] N. Liao, On the modulus of continuity of solutions to nonlocal parabolic equations, J. Lond. Math. Soc. (2), 110 (3) (2024), Paper No. e12985, 30 pp.

On the Hölder differentiability of fractional p -harmonic functions

Schedule: July 10 11:00-11:30 Room 430

Davide Giovagnoli

University of Bologna, Italy

Co-Author(s): David Jesus and Luis Silvestre

Abstract:

In this talk, we present a recent result, obtained with David Jesus (KAUST) and Luis Silvestre (University of Chicago), establishing that solutions to the homogeneous fractional p -laplace equation enjoy Hölder differentiability whenever $2 \leq p < \frac{2}{1-s}$ extending the well-known regularity theory from the local to the nonlocal setting.

Different assumptions in vectorial elliptic problems with a focus on the quasilinear case

Schedule: July 9 18:30-19:00 Room 430

Marta Macrì

University of L'Aquila, Italy

Abstract:

This talk presents several structural assumptions used to prove existence and regularity for vectorial elliptic systems. In nonlinear settings, Uhlenbeck-type conditions, Landes-type assumptions, and more recent componentwise coercivity are frequently employed. In the quasilinear case, however, such hypotheses force all off diagonal coefficients to vanish, effectively decoupling the system. To address genuinely quasilinear, non-diagonal systems, one often imposes conditions on the support of the off diagonal coefficients. As a specific example, an existence and regularity result will be discussed for a quasilinear elliptic system with a drift term.

Unified regularity properties for minimizers under double-phase and exponential growth

Schedule: July 10 9:00-9:30 Room 430

Antonella Nastasi

University of Palermo, Italy

Co-Author(s): Paolo Marcellini (University of Florence) and Cintia Pacchiano Camacho (Universidad Nacional Autonoma de Mexico)

Abstract:

In this talk we will present some general growth conditions for functionals, including the so-called natural growth, or polynomial, or growth conditions, or even exponential growth, in order to obtain that any local minimizer of the corresponding energy integral is locally Lipschitz continuous. In fact this is the fundamental step for further regularity; i.e., the general growth conditions a posteriori are reduced to a standard growth, with the possibility to apply the classical regularity theory. In other words, we reduce some classes of non-uniform elliptic variational problems to a context of uniform ellipticity. This is a joint work with Paolo Marcellini and Cintia Pacchiano Camacho.

Carleson-type removability for p -parabolic equations

Schedule: July 10 15:30-16:00 Room 430

Leah Schaetzler

Aalto University, Finland

Co-Author(s): Michał Borowski, Theo Elenius, and David Stolnicki

Abstract:

In this talk, I will characterize removable sets for Hölder continuous solutions to degenerate PDEs of parabolic p -Laplace type. I will give sufficient and necessary conditions for a set to be removable in terms of an intrinsic parabolic Hausdorff measure, which depends on the considered Hölder exponent. Our method of proof for the sufficient condition only relies on fundamental properties of the obstacle problem and supersolutions and is applicable to a wide class of operators. To obtain the necessary condition, we establish the Hölder continuity of solutions to measure data problems under a certain decay assumption on the considered measure. The talk is based on joint work with Michał Borowski, Theo Elenius, and David Stolnicki.

Fractional diffusion in heterogeneous media with a discontinuous coefficient

Schedule: July 10 8:30-9:00 Room 430

Ana Jacinta Soares

Centre of Mathematics, University of Minho, Portugal

Co-Author(s): E. Abreu, A. Azevedo, J. Guevara, L. Santos

Abstract:

We consider a flow problem in heterogeneous porous media with strongly varying properties. Such situations naturally arise in practical applications, particularly in petroleum reservoir engineering and groundwater flow, where abrupt changes in the medium induce discontinuous coefficients. This motivates the study of a nonlocal diffusion model involving a fractional gradient operator with a spatially varying and discontinuous coefficient $\beta(x) \geq \beta_* > 0$, capturing multiscale effects and anomalous transport phenomena. We construct a family of approximating problems by combining a regularizing diffusion term with a suitable approximation procedure. The analysis is carried out in an appropriate functional framework for weak solutions. We establish existence, positivity, and continuous dependence on the data, and derive uniform a priori estimates. These estimates allow us to pass to the limit in the approximating problems and obtain a solution to the limiting problem. This is joint work with Eduardo Abreu, Assis Azevedo, Julio Guevara, and Lisa Santos.

Improved moduli of continuity for degenerate phase transitions

Schedule: July 9 16:30-17:00 Room 430

Jose Miguel Urbano

KAUST, Saudi Arabia

Co-Author(s): Ugo Gianazza (Pavia) and Naian Liao (Salzburg)

Abstract:

We improve in two scenarios the current state-of-the-art modulus of continuity for weak solutions to the N -dimensional, two-phase Stefan problem featuring a p -degenerate diffusion: for $p = N \geq 3$, we sharpen it to

$$\omega(r) \approx \exp(-c|\ln r|^{\frac{1}{N}});$$

for $p > \max\{2, N\}$, we derive an unexpected Hölder modulus.

Existence and uniqueness of weak solutions to singular anisotropic elliptic problems

Schedule: July 10 8:00-8:30 Room 430

Eugenio Vecchi

ALMA MATER STUDIORUM - Universita' di Bologna, Italy

Abstract:

We consider a quasilinear singular anisotropic elliptic problem. Motivated by the celebrated paper by Lazer and McKenna, we provide necessary and sufficient conditions for the existence of weak solutions. We also discuss uniqueness of weak solutions. The talk is based on a joint work with F. Esposito and F. Oliva.

Fundamental regularity results for widely degenerate, doubly nonlinear anisotropic diffusion equations

Schedule: July 10 13:30-14:00 Room 430

Matias Vestberg

Uppsala Universitet, Sweden

Co-Author(s): Pasquale Ambrosio, Simone Ciani

Abstract:

We investigate fundamental regularity properties of solutions to a class of widely degenerate, doubly nonlinear anisotropic diffusion equations. Special attention is devoted to finding the weakest integrability assumption for the right-hand side which allows the arguments to be carried out.

H^{α} -Regularity for Doubly Nonlinear Equations

Schedule: July 10 11:30-12:00 Room 430

Yevgeniia Yevgenieva

Max Planck Institute for Dynamics of Complex Technical Systems, Germany

Co-Author(s): Simone Ciani, Eurica Henriques, Mariia Savchenko, Igor Skrypnik

Abstract:

Abstract: We study the local H^{α} -continuity of nonnegative solutions to the doubly nonlinear parabolic equation

$$u_t - \operatorname{div}(|Du|^m)^{p-2} Du^m = 0$$

in the mixed degenerate-singular cases, up to certain Barenblatt numbers:

$$0 < m(p-1) < 1, \quad p + N(m(p-1) - 1) > 0,$$

or

$$m(p-1) > 1, \quad \frac{2N}{N+1} < p < 2,$$

where N denotes the space dimension. The proof is based on the expansion of positivity and on a new version of integral Harnack-type inequalities, which are of independent interest.

Special Session 109 : Cluster Algebras, Hall Algebras and Their Applications

Organizer(s): Xueqing Chen , Fang Li , Min Huang

Introduction: Cluster algebras and Hall algebras lie at the interface of representation theory, topology, algebraic geometry and combinatorics. Since their introduction by Fomin and Zelevinsky in 2001, cluster algebras have profoundly influenced numerous areas including quiver representations, Teichmüller theory, Poisson geometry, dynamical system and mathematical physics. Hall algebras, originally conceived to study the category of finite-dimensional modules over finite fields, have found deep connections with quantum groups, Donaldson–Thomas invariants, and categorification. The proposed session aims to bring together leading experts, early-career researchers, and graduate students to explore current trends, open problems, and emerging applications of cluster algebras and Hall algebras. Potential topics for discussion encompass advancements in cluster algebras, quantum cluster algebras, cluster categories, monoidal categories, stability conditions, scattering diagrams, derived Hall algebra, cohomological Hall algebras, quiver Hecke algebras, and the interplay between cluster theory and Lie theory. We expect that this conference will promote the progress of some key issues in the frontier of mathematics.

Discreteness for the derived category of a graded skew-gentle algebra

Schedule: July 9 14:00-14:30 Room 204

Wen Chang

Shaanxi Normal University, Peoples Rep of China

Co-Author(s): HAIBO JIN, SIBYLLE SCHROLL, QI WANG

Abstract:

I will characterize silting-discreteness for the perfect derived categories of graded gentle and skew-gentle algebras. Specifically, for a graded gentle algebra, silting-discreteness is equivalent to its associated surface being of genus zero with non-zero winding numbers for all simple closed curves. We further extend this geometric characterization to graded skew-gentle algebras via orbifold surface models.

Fundamental relations in quantum cluster algebras

Schedule: July 9 17:30-18:00 Room 204

Xueqing Chen

University of Wisconsin-Whitewater, USA

Co-Author(s): Junyuan Huang, Ming Ding, Fan Xu

Abstract:

Let A_q be an arbitrary quantum cluster algebra with principal coefficients. We give the fundamental relations between the quantum cluster variables arising from one-step mutations from the initial cluster in A_q . Immediately and directly, we obtain an algebra homomorphism from the corresponding (untwisted) quantum group to A_q . This is a joint work with J. Huang, M. Ding and F. Xu.

Sign-coherence and tropical sign pattern for rank 3 real cluster-cyclic exchange matrices

Schedule: July 9 15:00-15:30 Room 204

Zhichao Chen

University of Science and Technology of China, Peoples Rep of China

Co-Author(s): Ryota Akagi

Abstract:

We study the sign-coherence of c -vectors for rank 3 real cluster-cyclic skew-symmetrizable cluster algebras. The sign-coherence property was conjectured by Fomin-Zelevinsky and proved in the integer skew-symmetrizable case by Gross-Hacking-Keel-Kontsevich. We extend this result to the rank 3 real cluster-cyclic setting. In addition, we establish a self-contained recursion and a monotonicity property for these c -vectors, and show that they arise as roots of certain quadratic equations. As applications, we prove that the exchange graphs of the associated C -patterns and G -patterns are 3-regular trees. We also investigate tropical sign patterns and realize the dihedral group $\mathcal{D}_6$ via cluster mutations. This is a joint work with Ryota Akagi.

Representations of bound quivers over the virtual field and their Ringel-Hall algebras

Schedule: July 7 17:30-18:00 Room 204

Changjian FU

Sichuan University, Peoples Rep of China

Abstract:

The theory of quiver representations over the virtual field $\mathbb{F}_1$ can be naturally extended to bound quivers involving monomial and commutativity relations. We further investigate Tits's philosophy on $\mathbb{F}_1$ by examining the Ringel-Hall algebras associated with specific classes of bound quivers, including Nakayama bound quivers and gentle one-cycle quivers $\Lambda(n-1, 1, 1)$. Our findings extend and refine the results of Szczesny for quivers of type A_n and cyclic quivers.

Ring theoretic approach to double centralizer property and applications

Schedule: July 7 18:30-19:00 Room 204

JUN HU

Beijing Institute of Technology, Peoples Rep of China

Abstract:

The double centralizer property is one of the most fundamental principles in Lie theory and representation theory. It underpins many classical results such as Schur-Weyl duality, which connects the representations of general linear Lie algebras and symmetric groups via mutual centralization on tensor spaces. I will introduce a ring theoretic approach (by Auslander and Solberg, K{\o}nig, Slung{\aa}rd and Xi, etc) to the proof of the double centralizer property in many examples, and I will talk about some of their generalizations and applications.

The quantum necklace Lie algebra and the HOMFLYPT skein algebra

Schedule: July 9 16:30-17:00 Room 204

Hiroaki Karuo

Gakushuin University, Japan

Co-Author(s): Shunsuke Tsuji

Abstract:

In the classical setting, it is known that the necklace Lie algebra and a graded quotient of the Goldman Lie algebra are isomorphic. This is an example of intersection between 2-dimensional topology and representation theory. There are quantizations of the necklace Lie algebra and the Goldman Lie algebra, called the quantum necklace Lie algebra and the HOMFLYPT skein algebra respectively. However, we did not know any relation between them as the classical setting. In this talk, we define an appropriate filtration on the HOMFLYPT skein algebra and construct an isomorphism between the quantum necklace Lie algebra and the graded quotient of the HOMFLYPT skein algebra. This gives us interactive applications, e.g., a topological interpretation of the quantum necklace Lie algebra and bases of the graded quotient of the HOMFLYPT skein algebra. This is a joint work with Shunsuke Tsuji (Meiji University). If time permits, I will explain the formality problem of the HOMFLYPT skein algebra related to the Kashiwara--Vergne problem.

Exceptional curves and quantum loop algebras

Schedule: July 7 18:00-18:30 Room 204

Ming Lu

Sichuan University, Peoples Rep of China

Co-Author(s): Zhongwei Fang, Shiquan Ruan

Abstract:

Schiffmann and Dou-Jiang-Xiao use the Hall algebras of weighted projective lines to realize quantum loop algebras of simply-laced type. In this talk, we generalize their results, and use the Hall algebras of exceptional curves to realize the quantum loop algebras associated to the corresponding valued star-shaped graphs. In particular, we are able to realize (twisted and untwisted) quantum affine algebras in Drinfeld new presentation.

Presentation of rational Schur algebras

Schedule: July 7 17:00-17:30 Room 204

Frantisek Marko

The Pennsylvania State University, USA

Co-Author(s): Frantisek Marko

Abstract:

The rational Schur algebra $S(n, r, s)$ over an arbitrary ground field K is represented as a quotient of the distribution algebra $\text{Dist}(G)$ of the general linear group $G = \text{GL}(n)$ by an ideal $I(n, r, s)$. We provide an explicit description of the generators of $I(n, r, s)$. Over fields K of characteristic zero, we complete a presentation of $S(n, r, s)$ in terms of generators and relations originally considered by Dipper and Doty, and then followed up by Donkin. The explicit presentation over ground fields of positive characteristics is new.

Modulated graphs with potentials and skew-symmetrizable cluster algebras

Schedule: July 9 9:30-10:00 Room 204

Lang Mou

UC Davis, USA

Abstract:

Cluster algebras in the skew-symmetric case admit a powerful categorification through representations of quivers with potentials, following the work of Derksen-Weyman-Zelevinsky. Extending this picture to the skew-symmetrizable case remains an important open problem. Modulated graphs with potentials generalize quivers with potentials and thus provide a promising candidate for such an extension. In this talk, I will present a mutation theory for modulated graphs with potentials and discuss how their representations may be used to categorify certain skew-symmetrizable cluster algebras. The goal is to suggest a representation-theoretic framework that parallels the skew-symmetric theory while capturing new phenomena arising in the skew-symmetrizable setting.

Skein algebras on punctured surfaces

Schedule: July 9 8:30-9:00 Room 204

Linhui Shen

Michigan State University, USA

Co-Author(s): Zhe Sun, Daping Weng

Abstract:

We begin with a concrete example of Poisson structures associated with the cluster A-algebra from the Markov quiver. Although its Poisson bracket is not log canonical with respect to any cluster seed, it is nevertheless compatible with cluster mutations. We generalize this Poisson structure to the Fock-Goncharov moduli space $A_{\{G,S\}}$ associated with punctured surfaces. When G is SL_3 , we construct a quantization of these Poisson structures, providing a natural generalization of the Roger-Yang Skein algebra. This is joint work in progress with Zhe Sun and Daping Weng.

Webs and their intersections

Schedule: July 9 14:30-15:00 Room 204

Zhe Sun

University of Science and Technology of China, Peoples Rep of China

Co-Author(s): Daniel Douglas, Linhui Shen, Daping Weng, Zhihao Wang, Tsukasa Ishibashi, Wataru Yuasa

Abstract:

G-Webs as certain trivalent graphs on the surfaces, appear naturally in the G-skein algebra and its classical limit the regular function ring of the G character variety. I will explain how we introduce their intersection number to parameterize a basis of the algebra for SL_3 (joint work with Daniel Douglas, Linhui Shen, Daping Weng, Zhihao Wang) and Sp_4 (joint work with Tsukasa Ishibashi, Wataru Yuasa).

Quantum cluster realization for projected stated SL_n -skein algebras

Schedule: July 9 17:00-17:30 Room 204

Zhihao Wang

Korea Institute for Advanced Study, Peoples Rep of China

Co-Author(s): Min Huang

Abstract:

In this talk, I will review the definition of the (reduced) stated SL_n -skein algebra associated to a punctured bordered surface (or marked surface). I will then introduce a quantum cluster algebra structure on the skew field of fractions of the reduced stated SL_n -skein algebra in the case where the surface has no interior punctures. Furthermore, I will show that the reduced stated SL_n -skein algebra embeds into the corresponding quantum cluster algebra when each connected component of the surface contains at least two punctures. In particular, every stated arc is a cluster variable up to multiplication by frozen variables. This is joint work with Min Huang.

Boundary Measurement Maps on Legendrian Weaves

Schedule: July 9 9:00-9:30 Room 204

Daping Weng

University of North Carolina at Chapel Hill, USA

Co-Author(s): Yoon Jae Nho

Abstract:

Boundary measurement maps were first introduced by Postnikov as a tool to parametrize positroid cells in Grassmannians. They depend on the choices of a reduced plabic graph and a perfect orientation of the graph. In my dissertation, I showed that the boundary measurement maps of the top cells of Grassmannians compute the F-polynomials for DT transformations. In recent years, a new combinatorial tool called Legendrian weave was introduced by Casals and Zaslow, and it can be used to describe cluster structures on braid varieties. In this talk, I will define a new family of boundary measurement maps on Legendrian weaves, which parametrize (an open torus of) the flag moduli space in terms of weighted cycles on weaves. I will discuss how to use these boundary measurement maps to recover F-polynomials for DT transformations and their connection to the spectral networks of Gaiotto-Moore-Neitzke. This is based on joint work in progress with Yoon Jae Nho.

Root categories and Lie groups

Schedule: July 7 16:30-17:00 Room 204

Jie Xiao

Beijing Normal University, Peoples Rep of China

Abstract:

D. Happel introduced the root category as a two-periodic orbit triangulated category R of the derived category of Dynkin quiver. The Gabriel Theorem can be stated with the Auslander-Reiten quiver of R , not only for the positive roots Φ^+ but also the whole root system Φ . We introduce here a process to build up semi-simple Lie algebras and Chevalley groups via Hall algebra approach. The construction can be applied to a realization of compact real form and maximal compact subgroups from the root category R , and obtain the Peter-Weyl Theorem and the Plancherel Theorem for compact groups. This is a joint work with Buyan Li.

Skein and cluster algebras of unpunctured surfaces for rank 2 simple Lie algebras

Schedule: July 9 13:30-14:00 Room 204

Wataru Yuasa

Hiroshima University, Japan

Co-Author(s): Tsukasa Ishibashi

Abstract:

This talk surveys recent developments in the relation between skein algebras and quantum cluster algebras for rank-two simple Lie algebras $\mathfrak{g} = \mathfrak{sl}_3, \mathfrak{sp}_4, \mathfrak{g}_2$. I will explain how $\mathfrak{g}$ -webs on unpunctured marked surfaces are related to quantum cluster algebras associated with moduli spaces of decorated local systems on the surface. The main goal of the talk is to present the general picture, in particular, how one constructs embeddings of skein algebras into the corresponding quantum cluster algebras. I will also present explicit examples of $\mathfrak{g}$ -webs corresponding to cluster variables.

Special Session 110 : Stochastic Dynamics

Organizer(s): Beom-Seok Han , Jae-Hwan Choi

Introduction: Stochastic dynamics plays a central role in the mathematical modeling of systems influenced by randomness, ranging from stochastic partial differential equations to interacting particle systems and random networks. In recent years, significant progress has been made in understanding the qualitative and quantitative properties of solutions to nonlinear and nonlocal stochastic equations, particularly those driven by Lévy processes, colored noise, or white noise. These include questions of well-posedness, Sobolev regularity, and space-time behavior, which are essential in analyzing long-time dynamics and stability. On the discrete side, models such as Glauber dynamics and exponential random graph models provide insight into the evolution of complex systems, where tools like mixing time and spectral gap estimates become crucial. These settings bring together techniques from stochastic analysis, spectral theory, and statistical mechanics. This session aims to bring together researchers working at the intersection of probability, analysis, and dynamical systems, with a focus on stochastic models that exhibit nontrivial spatial or temporal structure. The session seeks to showcase recent progress in mathematical theory and techniques relevant to these dynamics.

Heat kernel estimates for anisotropic jump processes and Dirichlet problems

Schedule: July 7 8:00-8:30 Room 738

Jaehoon Kang

Hankyong National University, Korea

Abstract:

In this talk, we consider symmetric jump processes with anisotropic jumping kernels given by unions of symmetric cones. We first review heat kernel estimates for such processes in the whole space and discuss their main features. We then briefly discuss the problem of Dirichlet heat kernel estimates in domains and some of the difficulties arising from anisotropy. We conclude with a discussion of an approach and some related computations.

AN EXISTENCE AND UNIQUENESS THEORY TO STOCHASTIC PARTIAL DIFFERENTIAL EQUATIONS WITH PSEUDO-DIFFERENTIAL OPERATORS

Schedule: July 7 16:30-17:00 Room 738

Ildoo Kim

Korea university, Korea

Co-Author(s): Jae-Hwan Choi

Abstract:

In this talk, we introduce a new weak formulation to guarantee existence and uniqueness of a solution to stochastic partial differential equations with pseudo-differential operators whose symbols are allowed to be signchanging.

The Dirichlet problem for stochastic partial differential equations (SPDEs) with nonlocal operators in $C^{1,\sigma}$ open sets

Schedule: July 7 17:00-17:30 Room 738

Kyeong Hun Kim

Korea University, Korea

Co-Author(s): Junhee Ryu

Abstract:

In this talk I will introduce a Sobolev regularity theory for the Dirichlet problem of SPDEs having spatial non-local operators in $C^{1,\sigma}$ open sets. I will consider substantially large classes of nonlocal operators and generalized Gaussian noise. The existence and uniqueness of strong solutions in weighted Sobolev spaces will be introduced, along with maximal L_p -regularity estimates for the solutions.

Heat kernel estimates for Dirichlet forms degenerate at the boundary

Schedule: July 7 8:30-9:00 Room 738

Panki Kim

Seoul National University, Korea

Abstract:

In this talk, we discuss estimates on the heat kernels of discontinuous symmetric Markov processes including ones with jump kernels degenerate at the boundary. There are new forms of the heat kernels estimates qualitatively different from all previously known heat kernel estimates. We also discuss the processes killed either by a critical potential or upon hitting the boundary. Their heat kernel estimates have the approximate factorization property with survival probabilities decaying as a power of the distance to the boundary, where the power depends on the critical potential. This talk is based on joint papers with Soobin Cho, Renming Song and Zoran Vondracek.

Transience time of the subcritical facilitated exclusion process

Schedule: July 7 14:00-14:30 Room 738

Seonwoo Kim

Yonsei University, Korea

Co-Author(s): Oriane Blondel, Clement Erignoux, Sanha Lee

Abstract:

In this talk, we consider the facilitated exclusion process on the one-dimensional discrete N -torus. Because of the facilitating mechanism, the process freezes in finite time if the particle density of the initial configuration is subcritical, i.e., if it is smaller than (or equal to) $1/2$. We prove that, starting from any subcritical Bernoulli product measure, the correct scale of the transience/freezing time is of order $\log^3 N$. Based on a joint work with Oriane Blondel, Clement Erignoux and Sanha Lee.

Dynamical Methods in Random Matrix Theory and Applications to Correlated Models

Schedule: July 7 14:30-15:00 Room 738

JAEHUN LEE

Institute of Science and Technology Austria (ISTA), Austria

Abstract:

We review a recently developed dynamical method in random matrix theory that extends universality results to a broader class of random matrices. A key idea of the method is to derive generalized local laws by means of Green function comparison along two different stochastic flows. We will explain this approach with particular emphasis on correlated random matrices. As an application, we will also discuss linear eigenvalue statistics for correlated random matrix models.

Gamma Expansion of the Large Deviation Rate Functional for Diffusion Processes

Schedule: July 7 15:00-15:30 Room 738

Jungkyoung Lee

Inha University, Korea

Co-Author(s): Claudio Landim, Mauro Mariani

Abstract:

The level two large deviation rate functional for a Markov process is closely related to its long-time behavior. When the process exhibits metastability, in particular a hierarchical structure across multiple time scales, this metastable behavior can be characterized through a Gamma expansion of the rate functional as established in Bertini, Gabrielli and Landim (Ann. Appl. Probab. 34(4): 3820-3869, 2024). In this talk, we discuss the Gamma expansion of the large deviation rate functional for reversible diffusion processes. This talk is based on joint work with Claudio Landim and Mauro Mariani.

Sub-critical Exponential random graphs

Schedule: July 7 13:30-14:00 Room 738

Kyeongsik Nam

KAIST, Korea

Co-Author(s): Shirshendu Ganguly; Kyeongsik Nam

Abstract:

The exponential random graph model (ERGM) is a central object in the study of canonical ensembles in statistical physics. Due to the lack of exact solvability, many basic questions have remained unanswered. In this talk, I will introduce a series of concentration of measure results for the ERGM throughout the entire sub-critical regime, including a Poincare inequality and Gaussian concentration.

Boundedness of non-local operators with variable coefficients: probabilistic approach and applications

Schedule: July 7 9:30-10:00 Room 738

Daehan Park

Kangwon National University, Korea

Co-Author(s): Jae-Hwan Choi, Jaehoon Kang

Abstract:

There has been growing interest in non-local operators in both analysis and probability. In particular, the structure of jumping kernels is closely connected to Lévy processes, with the fractional Laplacian serving as the most fundamental example. In this presentation, we consider the boundedness of the non-local operators having variable coefficients in weighted Lebesgue spaces. We also provide some applications such as regularity theory of evolution equations and elliptic-type equations in weighted Lebesgue spaces and Krylov-type estimate for the processes generating our operators.

L_p -estimates for nonlocal equations with general Lévy measures

Schedule: July 7 17:30-18:00 Room 738

Junhee Ryu

KIAS, Korea

Co-Author(s): Hongjie Dong

Abstract:

In this talk, we consider time-dependent nonlocal operators associated with general Lévy measures of order $\sigma \in (0, 2)$. We allow the class of Lévy measures to be very singular and impose no regularity assumptions in the time variable. Continuity of the operators and the unique strong solvability of the corresponding nonlocal parabolic equations in L_p spaces are established. We also demonstrate that, depending on the ranges of σ and d , the operator can or cannot be treated in weighted mixed-norm spaces.

Inviscid Limit for the Two-Dimensional Navier-Stokes Equations: A Stochastic Lagrangian Approach

Schedule: July 7 15:30-16:00 Room 738

Jinsol Seo

KIAS (Korea Institute for Advanced Study), Korea

Co-Author(s): Jae-Hwan Choi (KIAS), Chanwoo Kim (UW-Madison), and Dohyun Kwon (Yonsei University)

Abstract:

I will discuss recent progress on the vanishing-viscosity limit from the two-dimensional Navier-Stokes equations to the Euler equations. Our approach is both Lagrangian and probabilistic. First, we develop a stochastic analogue of the DiPerna-Lions theory to construct and control stochastic Lagrangian flows associated with the viscous dynamics. Second, we establish a large-deviation principle that quantifies the convergence to the Euler dynamics.

Nonhomogeneous boundary condition for spectral nonlocal operators

Schedule: July 7 9:00-9:30 Room 738

Vanja Wagner

University of Zagreb, Croatia

Co-Author(s): Ivan Bio\v{c}i\v{c}

Abstract:

The main interest of this talk will be the study of (semi-)linear nonlocal elliptic problems driven by spectral-type operators of the form $\psi(-L|_D)$ in bounded $C^{1,1}$ domains $D \subset \mathbf{R}^d$. Here ψ is a complete Bernstein function and $L|_D$ is the generator of a killed unimodal Lévy process. We will present the general framework that covers and extends the theory of the spectral and interpolated fractional Laplacian. The focus will be on the analysis of the nonhomogeneous boundary condition via a weak L^1 trace-like boundary operator. This operator is formulated in terms of the Poisson potential with respect to the $d - 1$ Hausdorff measure on ∂D . The methodology combines stochastic process techniques, potential theory, and spectral analysis.

Instantaneous shrinking of the support of solutions to stochastic PDEs.

Schedule: July 7 18:00-18:30 Room 738

Jaeyun Yi

Korea Institute for Advanced Study, Korea

Co-Author(s): Beom-Seok Han, Kunwoo Kim

Abstract:

In this talk, we discuss the instantaneous shrinking of the support of solutions to one-dimensional parabolic stochastic PDEs driven by space-time white noise. It is well known that if the initial data has compact support, then the solution also has compact support for all later times. In deterministic cases, a much stronger result holds: the solution has compact support immediately after the initial time if the initial data merely vanishes uniformly at infinity. We show that a class of parabolic SPDEs also exhibits instantaneous shrinking. In particular, if the uniqueness in law holds, then all nonnegative solutions exhibit instantaneous shrinking.

Special Session 111 : Evolution Equations and Operator Semigroups: Theory and Applications

Organizer(s): Christian Budde

Introduction: Evolution equations and operator semigroups lie at the heart of modeling dynamic systems across physics, biology, engineering, and beyond. This session aims to unite mathematicians and applied scientists to explore cutting-edge advances, address emerging challenges, and showcase innovative applications of these foundational tools. Focus areas include well-posedness, asymptotic behavior, nonlinear dynamics, stochastic perturbations, and numerical methods. Applications span control theory, fluid dynamics, population dynamics, and mathematical biology, emphasizing the translation of abstract theory into real-world solutions. The session will foster interdisciplinary dialogue through invited talks, contributed presentations, and posters, encouraging collaboration between theorists and practitioners. A key goal is to highlight novel methodologies—such as integro-differential techniques, fractional calculus, and non-autonomous systems—while addressing open problems in both classical and modern frameworks. We particularly welcome contributions bridging abstract operator theory with applied contexts, including infinite-dimensional systems and data-driven approaches. Early-career researchers are urged to participate, enriching the community's future. Join us to exchange ideas, stimulate breakthroughs, and shape the next generation of research in this vibrant field. Submit your work and engage in discussions that transcend traditional boundaries, driving progress from theory to impactful applications.

Perturbations of non-autonomous second-order abstract Cauchy problems

Schedule: July 6 15:00-15:30 Room 432

Christian Budde

University of the Free State, So Africa

Co-Author(s): Christian Seifert

Abstract:

We present time-dependent perturbations of second-order non-autonomous abstract Cauchy problems associated to a family of operators with constant domain. We make use of the equivalence to a first-order non-autonomous abstract Cauchy problem in a product space, which we elaborate in full detail. As an application we provide a perturbed non-autonomous wave equation.

Generation theorems via affine resolvent decomposition

Schedule: July 6 14:00-14:30 Room 432

Adam Gregosiewicz

Lublin University of Technology, Poland

Abstract:

We present a simple method for proving generation results for strongly continuous semigroups and cosine functions via resolvent decomposition. Let A be a closed linear operator on a Banach space and suppose that the domain of A consists of elements f satisfying a boundary/transmission condition of the form $\Phi f = 0$ for a linear functional Φ . In many concrete problems, Φ is a finite sum of simpler functionals, say $\Phi = \sum \phi$. Under a mild nondegeneracy condition on the kernel of $\lambda - A$, we show that for every λ in the resolvent sets of all $A|_{\ker \phi}$ we have

$$(\lambda - A)^{-1} = \sum_{\phi} \alpha_{\lambda, \phi} (\lambda - A|_{\ker \phi})^{-1}$$

with $\alpha_{\lambda, \phi} = \phi h / \Phi h$, where h is a fixed nonzero element of the kernel of $\lambda - A$. That is, the resolvent of A is an affine (or even convex) combination of simpler resolvents. Combining this identity with standard criteria (the Hille--Yosida theorem for semigroups and the Sova--Da Prato--Giusti theorem for cosine functions) yields a family of generation theorems: if each $A|_{\ker \phi}$ is a generator and the coefficients $\alpha_{\lambda, \phi}$ satisfy natural regularity conditions, then A is a generator as well. As applications, we obtain generation results beyond the purely Markov/Feller setting and prove the existence of cosine functions associated with skew and snapping out Brownian motions on star graphs. Moreover, we show that skew Brownian motion can be approximated by snapping out Brownian motion, illustrating how resolvent decompositions translate structural boundary information into concrete evolution families. References [1] A.~Gregosiewicz, Resolvent decomposition with applications to semigroups and cosine functions, Math. Ann. 391 (2025), 4011--4035.

Weak hypocoercivity for operator semigroups

Schedule: July 6 16:30-17:00 Room 432

Martin Grothaus

RPTU University Kaiserslautern-Landau, Germany

Abstract:

Motivated by problems from Industrial Mathematics we further developed the concepts of hypocoercivity. The original concepts needed Poincaré inequalities and were applied to equations in linear finite dimensional spaces. Meanwhile we can treat equations in manifolds or even infinite dimensional spaces. The condition giving micro- and macroscopic coercivity we could relax from Poincaré to weak Poincaré inequalities. In this talk an overview and many examples are given.

General concept of almost periodicity and applications to functional differential equations

Schedule: July 6 17:00-17:30 Room 432

Jaqueline Mesquita

Universidade Estadual de Campinas, Brazil

Co-Author(s): M. Bohner and R. Murakami

Abstract:

We introduce a general notion of almost periodic functions that extends the classical definition while encompassing a much broader class of functions. This new framework allows us to generalize several results, including nonperiodic averaging principles. We then apply these results to functional differential equations.

Heat Kernels and Geometry on Metric Graphs

Schedule: July 6 17:30-18:00 Room 432

Delio Mugnolo

FernUniversität in Hagen, Germany

Abstract:

The heat content of a domain, originally explored by Davies and van den Berg, is defined via the heat kernel of the heat equation. Much like the ground state energy, its significance lies in its ability to encode fundamental geometric properties. In this talk, we extend these concepts to the setting of metric graphs and establish new geometric bounds for this quantity. By employing graph surgery and more refined analytical tools, we demonstrate how these bounds facilitate a novel approach to geometric inverse problems on graphs.

Two-Dimensional Keller-Segel-Navier-Stokes System of Potential Type

Schedule: July 6 13:30-14:00 Room 432

Gabriela Planas

Universidade Estadual de Campinas, Brazil

Co-Author(s): D. Barbosa (Brazil) and F. Guill\'en-Gonz\'alez (Spain)

Abstract:

In this talk, we study a Keller-Segel-Navier-Stokes system posed on a two-dimensional domain, describing the interaction of a cell density with two chemical signals: an attractive signal that is consumed by the cells and a repulsive signal that is produced by them. The model incorporates general consumption and production rates together with a generalized logistic growth law for the cell population. We impose no-flux boundary conditions on the cell density and chemical concentrations, along with Dirichlet boundary conditions for the fluid velocity field. Under suitable conditions linking the chemotactic sensitivities, attraction and consumption rates, and the strength of logistic competition, we prove the existence of global classical solutions to the system.

Two Approximation Schemes for Walsh's Spider Process

Schedule: July 6 14:30-15:00 Room 432

Elzbieta Ratajczyk

Lublin University of Technology, Poland

Co-Author(s): Adam Bobrowski

Abstract:

Walsh's spider process is a diffusion on an infinite star-shaped graph S_k consisting of a single vertex connected to k half-lines. Away from the origin, it behaves as a one-dimensional Brownian motion along each ray, but exhibits a peculiar behavior at the origin. Roughly speaking, when the process reaches the central vertex, it instantaneously chooses an outgoing edge and starts a standard Brownian excursion on the i -th edge with probability α_i . We present two different approximation results for Walsh's spider. First, we derive the process as the diffusive scaling limit of a deterministic transport model with random velocity exchanges. Deterministic motions on k copies of S_k are perturbed by two stochastic mechanisms: interactions at interfaces located at the graphs' centers, and random jumps between different copies of the same edge. Second, we show that Walsh's spider process can be approximated by a snapping-out Brownian motion with large permeability coefficients. This yields an interpretation of Walsh's spider as a Brownian motion perturbed by the trace of a semi-permeable membrane located at the graph's center.

Special Session 112 : Nonlinear Dynamics: Methods, Models, and Applications

Organizer(s): Grzegorz Graff , Alfonso Ruiz-Herrera , José María Amigó

Introduction: This special session brings together researchers working at the forefront of nonlinear dynamics to explore recent advances in methods, models, and real-world applications. Nonlinear systems arise naturally across a wide range of disciplines—from physics and biomedicine to engineering and finance—and their analysis demands a blend of theoretical insight, computational tools, and data-driven techniques. The session will feature contributions on nonlinear time series analysis, showcasing techniques for uncovering hidden structures in complex data. Topics in dynamical systems will address both the qualitative and quantitative behavior of nonlinear models, examined from analytical and experimental perspectives. The session will also highlight recent developments in prediction techniques, including both classical approaches and modern methods based on machine learning. Special attention will be given to applications in population dynamics and epidemiology, where nonlinear models play a crucial role in understanding complex biological interactions, disease transmission, and intervention strategies. By fostering dialogue between theoretical development and practical implementation, this session aims to bridge disciplines and inspire new directions in the study of nonlinear phenomena.

Generalized synchronization and its detection via recurrent neural networks

Schedule: July 6 15:30-16:00 Room 739

Jose M Amigo

Universidad Miguel Hernandez, Spain

Abstract:

Given two unidirectionally coupled nonlinear systems, we speak of generalized synchronization when the responder "follows" the driver. Mathematically, this situation is implemented by a map from the driver state space to the responder state space termed the synchronization map. In nonlinear times series analysis, the framework of this communication, the existence of the synchronization map amounts to the invertibility of the so-called cross map, which is a continuous map that exists in the reconstructed state spaces for typical time-delay embeddings. The cross map plays a central role in some techniques to detect functional dependencies between time series. In this communication, we will discuss only the noiseless scenario, i.e., when noise is not present in the driver. To reveal generalized synchronization, we check the existence of synchronization maps using recurrent neural networks and predictability. The results demonstrate the capability of our method.

Deep learning for dynamical systems analyses

Schedule: July 6 16:30-17:00 Room 739

Roberto Barrio

University of Zaragoza, Spain

Co-Author(s): Roberto Barrio, Flavio Fenton, Alvaro Lozano, Ana Mayora-Cebollero, Carmen Mayora-Cebollero

Abstract:

Dynamical systems are usually analysed using standard techniques such as Lyapunov exponents. However, most of these classical methods are computationally expensive and often not feasible for studying real-world data. In this communication, we propose to use Deep Learning to overcome such limitations. We apply Deep Learning to detect chaotic regions in the parameter space of classical dynamical systems and to analyse chaotic dynamics in biological time series like experimental frog heart data. Furthermore, we use Deep Learning to detect more complex dynamical regimes by approximating Lyapunov exponents from single-variable time series. These analyses show the potential of Deep Learning in the study of dynamical systems.

A Second-Order Unconditionally Stable Scheme for Long-Time Dynamics of Nonlinear Models

Schedule: July 6 18:00-18:30 Room 739

Jack L Coleman

Missouri University of Science and Technology, USA

Co-Author(s): Jack Coleman, Daozhi Han, Xiaoming Wang

Abstract:

We propose a highly efficient second-order numerical scheme for approximating the long-time dynamics of a class of finite-dimensional nonlinear models arising in geophysical fluid dynamics. The method is unconditionally stable and requires solving only a fixed symmetric positive definite linear system at each time step. We prove that the numerical solutions remain uniformly bounded for all time and that the scheme accurately captures the long-time behavior of the underlying system. In particular, the global attractors and invariant measures of the scheme converge to those of the original model as the time step approaches zero. Numerical experiments on the Lorenz-96 system demonstrate that the scheme efficiently approximates long-time statistical properties and captures the invariant measures of the system.

A stage-structured seasonal model for the spread of flavescence dorée in vineyards

Schedule: July 7 9:30-10:00 Room 739

Attila Denes

Bolyai Institute, University of Szeged, Hungary

Co-Author(s): Abel Garab, Nigussie Abeye Shiferaw

Abstract:

Flavescence dorée is one of the most severe phytoplasma diseases affecting grapevines, posing an increasing threat to vineyards worldwide. The bacterial agent causing the disease is spread by the American grapevine leafhopper. We present a compartmental model for the spread of flavescence dorée incorporating stage structure in the vectors. To account for seasonal weather variations and the behaviour of the vectors, we consider periodic transmission, birth and death rates. We calculate the basic reproduction number as the spectral radius of a linear operator and show that it serves as a threshold parameter for disease persistence. Finally, we provide numerical simulations to assess the effect of varying key model parameters.

Flow-Aware Ellipsoidal Filtration for Persistent Homology of Recurrent Signals

Schedule: July 6 17:30-18:00 Room 739

Omer Eryilmaz

University of Birmingham, England

Co-Author(s): Omer Bahadir Eryilmaz, Cihan Katar, Max A Little

Abstract:

Recurrent signals generate trajectories that repeatedly return near previously visited states in state space. Analysing such data requires a principled notion of similarity that determines how local neighbourhoods are defined and scaled. This choice is also critical for topology-preserving denoising, where the aim is to reduce noise without distorting the underlying trajectory structure. We introduce a flow-aware ellipsoidal filtration for persistent homology based on a spatio-temporal covariance construction. The method estimates local flow geometry by combining temporal and spatial neighbours, and assigns an ellipsoid to each point, with orientation and axis lengths determined by local variances. In contrast to isotropic constructions such as the Vietoris–Rips filtration, this approach adapts to the directional structure of the data. When a dominant H_1 feature represents the main recurrent loop, its persistence interval provides a natural, data-driven scale selection rule. Experiments on synthetic and real signals show improved topology-preserving denoising and more accurate first-return-time estimation compared to isotropic filtrations.

Discrete Lyapunov functional for cyclic systems of differential equations with time-variable or state-dependent delay

Schedule: July 6 14:30-15:00 Room 739

Abel Garab

University of Szeged, Hungary

Co-Author(s): István Balázs

Abstract:

We consider nonautonomous cyclic systems of delay differential equations (DDEs) with variable delay. Under suitable feedback assumptions, we define an integer valued Lyapunov functional related to the number of sign changes of the coordinate functions of solutions. We prove that this functional possesses properties analogous to those established by Mallet-Paret and Sell for the constant delay case and by Krisztin and Arino for the scalar case. This may serve as an efficient tool in the study of the global dynamics of DDEs with variable delays. For example, the results can be applied to cyclic systems of DDEs with state-dependent delays to obtain a Morse-decomposition of the global attractor.

Topological and Dynamical Approaches to Cardiorespiratory Data Analysis

Schedule: July 6 15:00-15:30 Room 739

Grzegorz Graff

Gdansk University of Technology, Poland

Co-Author(s): Beata Graff, Pawel Pilarczyk, Maja Elstad, Krzysztof Narkiewicz

Abstract:

Physiological signals such as heart rate, blood pressure, and respiration reflect the dynamics of a complex and tightly coupled regulatory system. Their analysis therefore calls for mathematical methods capable of capturing nonlinear interactions, multiscale structure, and temporal variability. Among such approaches, ordinal pattern analysis and topological methods, including persistent homology, provide promising tools for investigating the organization of physiological data. The aim of this work is to study how these methods can be applied to the analysis of interactions within the cardiorespiratory system, with particular emphasis on the role of respiration in shaping cardiovascular dynamics. By comparing selected signal characteristics across physiological states and between healthy and pathological conditions, we seek to identify features that may indicate changes in regulatory mechanisms

Double-Partitions Homology for Coupling Complexity Analysis of Multivariate Time Series

Schedule: July 7 9:00-9:30 Room 739

Taichi Haruna

Tokyo Woman's Christian University, Japan

Co-Author(s): Taichi Haruna

Abstract:

Ordinal persistent homology (OPH) and its generalizations were proposed as a framework for investigating coupling complexity in multivariate time series. Total persistence (TP), as defined in OPH, is a measure of coupling complexity in the following sense: it is zero for completely synchronized time series, takes a specific small value with high probability for asynchronous time series satisfying a certain independence condition, and can be large somewhere between the two extreme cases. TP has been successfully applied to analyze coupling complexity in several high-dimensional nonlinear systems. In this presentation, we propose an alternative, simpler homological method to study coupling complexity in multivariate time series. In this method, we consider two sufficiently long time intervals separated in time and partition the set of time series using the ordinal patterns for each time interval. We construct a simplicial complex from the two partitions by assigning a simplex to each part of the partitions. We show that the first Betti number of the simplicial complex can serve as a coupling complexity measure better than TP: it takes zero not only in the synchronous case, but also in the asynchronous case with high probability.

Sparse modeling of high dimensional time series and the role of lag causality

Schedule: July 6 13:30-14:00 Room 739

Dimitris Kugiumtzis

Aristotle University of Thessaloniki, Greece

Co-Author(s): Petros Petridis

Abstract:

Machine learning and deep learning models are widely utilized for modeling and forecasting multivariate time series but they have no closed form and do not give insight onto the true dynamics. This study explores methods that elucidate the structural form of the equations representing the components of the multivariate time series and conducts a comparative analysis of their forecasting errors. Specifically, the study evaluates the performance of regression models bearing analytic form on multivariate time series of stochastic and nonlinear deterministic systems. These models are: 1) polynomial regression models, 2) the Sparse Identification of Nonlinear Dynamics (SINDy) algorithm and 3) symbolic regression models. In addition, we consider sparse versions of the above models by restricting the input lag variables to the most informative to the response, as found by the Partial Mutual Information from Mixed Embedding (PMIME) algorithm. The models are compared with respect to multi-step ahead prediction on multivariate time series of stochastic and deterministic systems of varying dimension. The results of the simulations highlight the importance of dimensionality reduction through lag variable selection in the autoregressive models of any of the three examined types.

A Unified Ordinal-Pattern Framework for Testing Temporal Symmetries in Time Series

Schedule: July 6 17:00-17:30 Room 739

Giorgio Micali

University of Twente, Netherlands

Co-Author(s): Annika Betken, Manuel Ruiz Marín

Abstract:

We propose a unified framework for testing temporal symmetries in time series based on the distribution of ordinal patterns. Existing ordinal-pattern approaches typically focus on specific symmetry properties, such as time reversibility, by testing equalities between selected pattern probabilities, often pairing each pattern with its reverse. These approaches implicitly induce a partition of the permutation space, restricting the scope of the analysis to predefined symmetry structures. Our framework generalizes this idea by allowing symmetry tests to be constructed from arbitrary partitions of the ordinal-pattern space, providing a flexible and systematic way to design tests for a wide range of temporal properties. Depending on the chosen partition, the proposed methodology recovers classical ordinal-pattern tests as special cases while enabling the exploration of previously unaddressed symmetry structures. We derive asymptotic results for the proposed test statistics under broad classes of stationary processes, ensuring theoretical validity. Extensive experiments on synthetic and real-world time series demonstrate that the proposed tests are highly sensitive to structural temporal asymmetries, while remaining fully data-driven, computationally efficient, and easy to implement.

Classes of multivariate ordinal patterns linked to motion

Schedule: July 7 8:30-9:00 Room 739

Alexander Schnurr

Siegen University, Germany

Co-Author(s): Svenja Fischer, Marco Oesting

Abstract:

The classification of movement in space is one of the key tasks in environmental science. Various geospatial data such as rainfall or other weather data, data on animal movement or landslide data require a quantitative analysis of the probable movement in space to obtain information on potential risks, ecological developments or changes in future. Usually, machine-learning tools are applied for this task. Yet, machine-learning approaches also have some drawbacks, e.g. the often required large training sets and the fact that the algorithms are often hard to interpret. We propose a classification approach for spatial data based on ordinal patterns. Ordinal patterns have the advantage that they are easily applicable, even to small data sets, are robust in the presence of certain changes in the time series and deliver interpretative results. They, therefore, do not only offer an alternative to machine-learning in the case of small data sets but might also be used in pre-processing for a meaningful feature selection. In this talk, we introduce the basic concept of multivariate ordinal patterns, classify them and provide the corresponding limit theorem. The approach is applied to rainfall radar data.

Investigating Dynamical Similarity of Unknown Systems through Time Series and Samples of Data

Schedule: July 6 14:00-14:30 Room 739

Justyna Signerska

Gdansk University of Technology, Poland

Abstract:

A key tool in comparing and classifying dynamical systems is the notion of topological conjugacy. In this talk, we consider the problem of testing (semi-)topological conjugacy between two trajectories arising from unknown dynamical systems when only finite samples of these trajectories are available. We will discuss a range of tests inspired by methods from topological data analysis and present various numerical examples demonstrating their effectiveness. Moreover, we will show that these methods can be applied to determine the optimal embedding dimension, referring to the well-known Takens' Embedding Theorem, which provides a theoretical framework for time series analysis in a wide range of applications. The talk is based on joint work with Pawel Dlotko (Dioscuri Centre in TDA), Michal Lipinski (IST Austria), and Marta Marszewska (Gdansk University of Technology and Dioscuri Centre in TDA).

Disease transmission on networks - when is a hypergraph not a hypergraph

Schedule: July 6 18:30-19:00 Room 739

Michael Small

University of Western Australia, Australia

Co-Author(s): Eugene Tan, Shannon D. Algar

Abstract:

Contact networks are a paradigmatic model for understanding disease transmission in heterogeneous populations. Typical methods approach this via an averaging over nodes of the same degree. We (with Moore and Wang) have shown that a modified concept of network dimension can achieve a better prediction of behaviour including endemic state in SIS models. Recent work has shifted attention to transmission on hypergraphs. In this setting the higher order connections are introduced to model higher order interaction processes and introduce additional complication to the analysis. We show that the dynamics observed in these higher order models is always equivalent to dynamics on a lower-order (network) model with time-varying disease parameters. While the hypergraphs may be better suited to modelling certain situations they do not introduce dynamical behaviour not present in lower order models.

Special Session 113 : Recent Advances in Uncertainty Quantification and Scientific Machine Learning with Applications to Complex Dynamical Systems

Organizer(s): Marios Andreou , Konstantinos Zygalakis , Nan Chen

Introduction: Turbulent dynamics prevail in many complex nonlinear dynamical systems, stochastic or not, used to model phenomena in geophysics, fluids, engineering, and neuroscience. Such systems are characterized by their high-dimensional state space and multiscale spatiotemporal features. In recent years, uncertainty quantification (for both forward and inverse problems) and scientific machine learning have been increasingly applied for their effective state estimation, parameter inference, optimal control, and system design. These methods enhance robustness, data completeness, and predictive skill in complex systems. They advance frameworks that utilize probabilistic approaches as computationally efficient surrogates for solving practical problems. This further enables the rigorous mathematical study and analysis of the model and forecast errors, facilitating their mitigation, optimization, and tuning. This special session will highlight recently developed fundamental mathematical theories and numerical algorithms for uncertainty quantification and machine-learning-assisted methods. A focal point will be their applications to various aspects of the study of complex dynamical systems.

Assimilative Causal Inference: Tracing Causes from Effects to Predict and Attribute Significant Events

Schedule: July 10 13:30-14:00 Room 827

Marios Andreou

University of Wisconsin-Madison, USA

Co-Author(s): Nan Chen, Erik Bollt

Abstract:

Causal inference is fundamental across scientific disciplines, yet state-of-the-art methods often struggle to capture instantaneous causal relationships in high-dimensional systems. This work introduces assimilative causal inference (ACI), a paradigm-shifting framework that reframes causality as a Bayesian inverse problem using data assimilation. Rather than measuring forward influence from causes to effects, ACI instead traces causality backwards by quantifying how incorporating future information from effects reduces the uncertainty in the estimated system state. As such, effects are interpolated onto causes, contrasting classical predictive approaches that extrapolate causes forward to identify effects. ACI dynamically determines causal interactions without observing candidate causes, accommodates short datasets, and scales efficiently to high dimensions. Crucially, it provides online tracking of causal roles, which may reverse intermittently, and facilitates rigorous criteria for the causal influence range (CIR) of a relationship. The ACI-based CIR metric is objectively defined, without empirical thresholds, and admits both forward- and backward-in-time formulations. The forward CIR quantifies the temporal reach of a cause, while the backward CIR traces the onset of triggers for an observed effect, enabling causal predictability and attribution in transient regimes. The effectiveness of ACI and its CIR framework is demonstrated on nonlinear dynamical systems showcasing intermittency, extreme events, and tipping points.

New results in feedback particle filter

Schedule: July 10 8:00-8:30 Room 827

Sumith Reddy Anugu

TU Ilmenau, Germany

Co-Author(s): Sumith Reddy Anugu (TU Ilmenau), Jana de Wiljes (TU Ilmenau), Gottfried Hastermann (TU Ilmenau)

Abstract:

Feedback particle filter is known to provide a way to compute the filter (conditional) distribution of the associated filtering model. In this talk, we present certain new results in the context of feedback particle filter. We first present the well-posedness of the associated Poisson equation (which is crucial to the implementation of the feedback particle filter) under certain easily verifiable sufficient conditions. Then, we introduce a new approximation procedure for the feedback particle filter (that is computationally more efficient), which makes use of a 'local' version of the associated Poisson equation.

Scalable Method for Unsupervised Reconstruction of Flow (SMURF) with application to clinical 4D flow MRI data

Schedule: July 10 12:00-12:30 Room 827

Ilias Bilonis

Purdue University, USA

Co-Author(s): Atharva Hans

Abstract:

Clinical 4D flow MRI can provide detailed measurements of cardiac blood flow, but current workflows rely on manual segmentation and post hoc velocity filtering, which introduce variability and reduce physical consistency. We introduce SMURF, a label-free framework that infers probabilistic geometry and velocity as implicit neural fields from magnitude and phase data through a measurement model. This coupling casts segmentation and velocity reconstruction as a single inference problem and enables evaluation on finer grids without retraining. In 12 pediatric cases (four Normal, eight Fontan), SMURF matches expert segmentations with surface offsets of ≈ 1 voxel (Normal) and ≈ 1.3 voxels (Fontan), reduces RMS divergence and vorticity-transport momentum residuals by roughly 70-80% relative to an FDA-cleared post-processing pipeline, and completes time-resolved segmentation and velocity reconstruction in 4.7-11.4 minutes per case, about five- to fifteen-fold shorter than reported semiautomatic post-processing. SMURF reduces reliance on expert-drawn segmentations and produces time-resolved segmentations and reconstructed flow fields that are more physically consistent from 4D flow MRI alone.

Learning data assimilation from artificial intelligence

Schedule: July 10 9:30-10:00 Room 827

Marc BOCQUET

\Ecole nationale des ponts et chauss\ees, France

Co-Author(s): Marc Bocquet and collaborators

Abstract:

We investigate the ability to discover data assimilation (DA) schemes meant for chaotic dynamics with deep learning. The focus is on learning the analysis step of sequential DA, from state trajectories and their observations, using a simple residual convolutional neural network, while assuming the dynamics to be known. Experiments are performed with low-order dynamics which display spatiotemporal chaos and for which solid benchmarks for DA performance exist. The accuracy of the states obtained from the learned analysis approaches that of the best possibly tuned ensemble Kalman filter, and is far better than that of variational DA alternatives. Critically, this can be achieved while propagating even just a single state in the forecast step. We investigate the reason for achieving ensemble filtering accuracy without an ensemble. We diagnose that the analysis scheme actually identifies key dynamical perturbations, mildly aligned with the unstable subspace, from the forecast state alone, without any ensemble-based covariances representation. This reveals that the analysis scheme has learned some multiplicative ergodic theorem associated to the DA process seen as a non-autonomous random dynamical system. This also suggests building a new class of efficient deep learning-based ensemble-free DA algorithms.

Multiscale Modelling and Data Assimilation for Sea Ice Dynamics

Schedule: July 10 11:00-11:30 Room 827

Quanling Deng

Yau Mathematical Sciences Center, Peoples Rep of China

Abstract:

Sea ice dynamics involve complex interactions across a wide range of scales, from individual floe collisions to large-scale coupled behaviour with the ocean and atmosphere. This talk presents a multiscale perspective on sea ice modelling and data assimilation, with an emphasis on connecting discrete floe-level dynamics to continuum descriptions suitable for larger-scale prediction and the corresponding sea ice rheology. After a brief introduction to the main features of sea ice and a short overview of major continuum approaches, I will introduce a multiscale modelling framework for sea ice floes and discuss how it captures essential physical mechanisms across scales. Building on this framework, I will then present a multiscale data assimilation approach designed to combine Lagrangian and Eulerian observational data in a coherent and flexible way. The talk will conclude with a brief discussion of ongoing efforts to incorporate machine learning tools into the assimilation pipeline, with the goal of improving predictive accuracy, robustness, and computational efficiency in sea ice modelling.

Spatial Jump Process Models for Estimating Antibody-Antigen Interactions

Schedule: July 10 16:30-17:00 Room 827

Samuel Isaacson

Boston University, USA

Abstract:

Surface Plasmon Resonance (SPR) assays are a standard approach for quantifying kinetic parameters in antibody-antigen binding reactions. Classical SPR approaches ignore the bivalent structure of antibodies, and use simplified ODE models to estimate effective reaction rates for such interactions. In this work we develop a new SPR protocol, coupling a model that explicitly accounts for the bivalent nature of such interactions and the limited spatial distance over which such interactions can occur, to a SPR assay that provides more features in the generated data. Our approach allows the estimation of bivalent binding kinetics and the spatial extent over which antibodies and antigens can interact, while also providing substantially more robust fits to experimental data compared to classical ODE models. I will present our new modeling and parameter estimation approach, and demonstrate how it is being used to study interactions between antibodies and spike protein. I will also explain how we make the overall parameter estimation problem computationally feasible via the construction of a surrogate approximation to the (computationally-expensive) particle model. The latter enables fitting of model parameters via standard optimization approaches.

Capturing Prediction Uncertainty in Data Assimilation

Schedule: July 10 9:00-9:30 Room 827

Tijana Janjic

KU Eichstaett Ingolstadt, Germany

Co-Author(s): Catherine George, Alireza Javanmardi, Eyke Huellermeier

Abstract:

Quantification of evolving uncertainties is required for both probabilistic forecasting and data assimilation in weather prediction. In current practice, the ensemble of model simulations is often used as primary tool to describe the required uncertainties. In idealized settings, using toy models that mimic convective situations, we explore two alternative approaches, so called stochastic Galerkin method which integrates uncertainties forward in time using a spectral approximation in the stochastic space and machine learning approach based on conformal prediction.

On the Potential and Pitfalls of Flow Matching for Probabilistic Forecasting

Schedule: July 10 10:30-11:00 Room 827

Soon Hoe Lim

KTH Royal Institute of Technology and Nordita, Sweden

Co-Author(s): Shizheng Lin, Michael Mahoney, N. Benjamin Erichson

Abstract:

Flow matching has emerged as a powerful paradigm for generative modeling. From the viewpoint of dynamical measure transport, it constructs continuous-time ODE samplers by prescribing probability paths that connect a base and a target distribution. In this talk, we discuss both the potential and pitfalls of flow matching for probabilistic forecasting of dynamical systems. We observe that forecasting performance is highly sensitive to the choice of probability path, motivating principled constructions that lead to improved computational efficiency and predictive performance on spatio-temporal dynamical system benchmarks. We then revisit flow matching in the empirical setting and analyze the structure of the induced velocity fields, uncovering connections between flow matching, memory effects, and nonparametric dynamical systems. This perspective leads to new sampling strategies and raises questions about the role of parameterization in learning dynamical systems from data.

Sequential Monte Carlo for Bayesian Inference Using Randomized Likelihoods

Schedule: July 10 15:30-16:00 Room 827

Josef Martinek

Heidelberg University, Germany

Co-Author(s): Julian Hofstadler, Alexander M.G. Cox, Robert Scheichl

Abstract:

In this talk we focus on Bayesian inverse problems in which the forward parameter-to-observable map is approximated in a stochastic way, for instance by Monte Carlo (MC) simulations. Such problems arise for example in uncertainty quantification of particle transport, where the parameter-to-observable map is defined through the solution of the Boltzmann equation. Approximating the likelihood with high accuracy requires MC simulations with many samples, which makes sampling from the posterior distribution expensive. We present an efficient method for sampling from the posterior based on pseudo-marginal sequential Monte Carlo (SMC) using likelihood tempering. To accelerate sampling from the posterior the method adopts a multilevel approach. A significant speedup is achieved compared to a single-level SMC using high-fidelity MC simulations while achieving the same error, which is verified theoretically and demonstrated by numerical experiments.

HCLimRep: a Foundation Model for capturing interactions between the atmosphere, ocean, and sea ice

Schedule: July 10 17:30-18:00 Room 827

Savvas Melidonis

Forschungszentrum Juelich GmbH, Germany

Co-Author(s): Savvas Melidonis, Ankit Patnala, Belkis Asma Semcheddine, Jehangir Awan, Simon Grasse, Kacper Nowak, Aleksei Koldunov, Julius Polz, Enxhi Kreshpa, Illaria Luise, Christian Lessig, Nikolay Koldunov, Thomas Jung, Martin Schultz

Abstract:

Climate change presents critical challenges to ecosystems and human society. Accurate projections of climate change and its consequences are essential for assessing climate policies and developing proactive strategies to mitigate extreme weather events. While conventional climate models - grounded in fluid dynamics and radiative transfer physics - have yielded valuable insights, they suffer from several shortcomings: inherent biases, coarse spatial resolution, structural errors, and considerable computational inefficiency. Within Helmholtz Foundation Model Initiative (HFMI), we introduce HClimRep, an AI-driven foundation model designed to capture the intricate coupled dynamics of the atmosphere, stratosphere, ocean, and sea-ice and to generate realistic climate simulations. HClimRep builds on the WeatherGenerator prototype - a EU funded HORIZON weather forecasting project - by expanding its architecture and training regime to deliver true climate projection capabilities. In this presentation we will outline the most recent advances of our project in subseasonal to seasonal forecasting and showcase a atmosphere-ocean downscaling downstream application. By harnessing transformer-based modelling, GPU-level optimization, and the latest developments at the intersection of high performance computing and AI, our overarching goal is to deliver a breakthrough climate research tool that deepens our understanding of the Earth system and underpins evidence based climate adaptation and policy decisions.

Dynamical Low-Rank Ensemble Kalman filtering

Schedule: July 10 8:30-9:00 Room 827

Fabio Nobile

Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland

Co-Author(s): Sebastien Riffaud, Thomas Trigo Trindade

Abstract:

We consider a high-dimensional time-continuously partially observed linear system of SDEs and the Ensemble Kalman filter (EnKF) to evolve the filtering distribution. To reduce computational complexity, we propose a dynamical low-rank approximation (DLR-EnKF), where particles evolve in a relatively small, online-computed, time-varying subspace at reduced cost. This allows for a significantly larger ensemble size compared with standard EnKF at equivalent cost, thereby lowering the Monte Carlo error and improving filter accuracy. Some theoretical properties, including a propagation-of-chaos result, will be presented. We then extend the framework to high-dimensional non-linear dynamical systems for efficient joint state-parameter estimation. We discuss, in particular, a time-integration strategy that combines the Basis Update & Galerkin scheme with forecast/analysis discretisation, and a DEIM-based hyper-reduction technique for efficient evaluation of nonlinear terms. We demonstrate the effectiveness, robustness, and computational advantages of the proposed approach on benchmark problems, including a state/parameter estimation problem for a reduced one-dimensional blood flow model of the human arterial system observed in only three spatial locations.

Geometric extremal graphical models

Schedule: July 10 11:30-12:00 Room 827

Ioannis IP Papastathopoulos

University of Edinburgh, Scotland

Co-Author(s): Lambert De Monte, XIndi Song

Abstract:

We introduce geometric extremal graphical models, a new framework for describing dependence in multivariate extreme events. The approach is based on a geometric representation of the limiting behaviour of suitably scaled random vectors with light-tailed margins. For block graphs, we show how different measures of extremal dependence propagate through the graph. We focus on measures connected to conditional extreme value theory, which are useful when extreme events occur in some variables without requiring all variables to be extreme at the same time. We also discuss the case of joint extreme behaviour, where several variables become extreme together. Together with recent work linking geometric ideas in multivariate extremes to practical statistical models, these results open the way to modelling high-dimensional extremes with complex dependence structures. ♦ Joint work with Jennifer L. Wadsworth ♦

Reduced-order models for data assimilation and uncertainty quantification of multiscale turbulent systems

Schedule: July 10 17:00-17:30 Room 827

Di Qi

Purdue University, USA

Co-Author(s): Di Qi and Jian-Guo Liu

Abstract:

A new strategy is presented for the statistical forecasts of multiscale nonlinear systems involving non-Gaussian probability distributions. The capability of using reduced-order models to capture key statistical features is investigated. A closed stochastic-statistical modeling framework is proposed using a high-order statistical closure enabling accurate prediction of leading-order statistical moments and probability density functions in multiscale complex turbulent systems. A new efficient ensemble forecast algorithm is developed dealing with the nonlinear multiscale coupling mechanism as a characteristic feature in high-dimensional turbulent systems. To address challenges associated with closely coupled spatio-temporal scales in turbulent states and expensive large ensemble simulation for high-dimensional complex systems, we introduce efficient computational strategies using the random batch method. Effective nonlinear ensemble filters are developed based on the nonlinear coupling structures of the explicit stochastic and statistical equations, which satisfy an infinite-dimensional Kalman-Bucy filter with conditional Gaussian dynamics. It is demonstrated that crucial principal statistical quantities in the most important large scales can be captured efficiently with accuracy using the new reduced-order model in various dynamical regimes of the flow field with distinct statistical structures.

Data assimilation with machine-learned dynamics

Schedule: July 10 14:00-14:30 Room 827

Daniel Sanz-Alonso

University of Chicago, USA

Co-Author(s): Nisha Chandramoorthy, Nathan Waniorek, Wenwen Li

Abstract:

Scientific machine learning is transforming the field of data assimilation by providing accurate and cheap-to-evaluate surrogate models for many dynamical systems. In the first part of this talk, I will show that Fourier Neural Operators (FNOs) enjoy polynomial sample complexity for estimating the solution map of a wide class of evolution PDEs. Our theory leverages that these PDEs can be accurately approximated via spectral methods, and that these numerical schemes can in turn be efficiently learned using FNOs. In the second part of this talk, I will show that ensemble Kalman filters with machine-learned surrogate models achieve long-time filter accuracy under standard observability assumptions on the true dynamics and observation models.

Global Convergence of Adjoint-Optimized Neural PDEs

Schedule: July 10 14:30-15:00 Room 827

Konstantinos Spiliopoulos

Boston University, USA

Abstract:

Many engineering and scientific fields have recently become interested in modeling terms in partial differential equations (PDEs) with neural networks, which requires solving the inverse problem of learning neural network terms from observed data in order to approximate missing or unresolved physics in the PDE model. The resulting neural-network PDE model, being a function of the neural network parameters, can be calibrated to the available ground truth data by optimizing over the PDE using gradient descent, where the gradient is evaluated in a computationally efficient manner by solving an adjoint PDE. These neural PDE models have emerged as an important research area in scientific machine learning. In this work, we study the convergence of the adjoint gradient descent optimization method for training neural PDE models in the limit where both the number of hidden units and the training time tend to infinity. Specifically, for a general class of nonlinear parabolic PDEs with a neural network embedded in the source term, we prove convergence of the trained neural-network PDE solution to the target data (i.e., a global minimizer). The theoretical results are illustrated and empirically validated by numerical studies.

Neural network surrogates with uncertainty quantification for inverse problems

Schedule: July 10 15:00-15:30 Room 827

Aretha L Teckentrup

University of Edinburgh, Scotland

Co-Author(s): Christian Jimenez Beltran, Antonio Vergari, Konstantinos Zygalakis

Abstract:

Inverse problems in differential equations are central to many scientific and engineering applications, requiring the estimation of model parameters based on noisy or incomplete observations. Traditional numerical methods for solving these problems are computationally expensive, particularly in Bayesian settings, where likelihood evaluations must be performed repeatedly in high-dimensional parameter spaces. In this talk, we investigate neural networks as surrogates to address these challenges. By incorporating a Laplace Approximation, our method efficiently approximates the forward model and provides uncertainty estimates. Compared to traditional methods, this approach significantly reduces computational costs while maintaining accurate posterior approximations. These findings underscore the potential of neural networks for scalable and reliable solutions to inverse problems in complex systems.

Special Session 114 : Recent Advances in Partial Differential Equations and Harmonic Analysis

Organizer(s): Irina Mitrea , Dorina Mitrea

Introduction: The session focuses on research problems at the interface between Partial Differential Equations (PDE) and Harmonic Analysis, with a special emphasis on the regularity of solutions to linear and nonlinear elliptic boundary value problems. Techniques originating from these fields have a long and distinguished history, driving many fundamental developments in various areas of mathematics and having important applications in physics and engineering. Recent results at the confluence of PDE and Harmonic Analysis have proven extremely potent in addressing a host of difficult and significant problems in Analysis. Progress in these fields continues to have a major impact on the study of boundary value problems arising in acoustics, heat diffusion, electrostatics, electrodynamics, thermodynamics, statistical mechanics, fluid dynamics, elasticity, general relativity, and quantum mechanics. This session will serve as an international forum for disseminating new advances at this active interface.

p-Ellipticity for Elliptic Systems with Complex Coefficients

Schedule: July 8 13:30-14:00 Room 823

Andrea Carbonaro

University of Genoa, Italy

Abstract:

We extend the concept of p-ellipticity for scalar elliptic operators---introduced by us in 2016---to the case of elliptic systems with complex coefficients. Although our condition turns out to be equivalent to a condition for systems (equally named) by Dindos, Li and Pipher (2021), the two approaches are different and yield different results. Our primary goal is to develop an algebraic and geometric framework for studying p-ellipticity in the systems setting. We investigate how the structural properties of fourth-order coefficient tensors determine the range of p-ellipticity, and how this range encodes the anisotropic and asymmetric features of the tensor. We also aim to explicitly determine or estimate the range of p-ellipticity for significant concrete systems and notable classes of tensors. As an application of our theory, we establish contractivity on L^p of the semigroup generated by the associated elliptic operators, under Dirichlet, Neumann, and mixed boundary conditions.

Shifted Maximal Functions and the Boundedness of Rough Singular Integral Operators

Schedule: July 8 15:00-15:30 Room 823

Andrew Haar

Charles University, Czech Rep

Abstract:

A classical problem at the intersection of harmonic analysis and PDE is the boundedness of the so-called Calderon commutators, which, not being of convolution type, require creative tools to analyze. Indeed, we will see a new approach to these pioneered by C. Muscalu in 2014 through shifted variants of certain square and maximal functions, which have gone on to become rather fashionable tools in the last decade, especially in the theory of multilinear singular integrals. We will see in the context of some recent results on multilinear Fourier multipliers how these shifted operators naturally appear. Then, we will conclude by briefly investigating how these results can be applied to prove boundedness for a general class of rough multilinear singular integrals, which include the Calderon commutators as a special case.

Inequalities of the electromagnetism for H^s lder continuous functions

Schedule: July 8 8:30-9:00 Room 823

Massimo Lanza de Cristoforis

Dipartimento di Matematica 'Tullio Levi-Civita', Italy

Abstract:

We plan to prove some classical inequalities of the electromagnetism for H^s lder continuous functions that may have infinite Dirichlet integral. Thus for functions that do not belong to the classical variational setting.

Low regularity solutions of the nonlinear Schrödinger equation on the spatial quarter-plane

Schedule: July 8 9:00-9:30 Room 823

Dionyssis Mantzavinos

University of Kansas, USA

Co-Author(s): Turker Ozsari

Abstract:

We will discuss the Hadamard well-posedness (existence, uniqueness and continuous dependence on the data) of the nonlinear Schrödinger equation with power nonlinearity formulated on the spatial quarter-plane with Sobolev initial data and nonhomogeneous Dirichlet boundary data in appropriate Bourgain-type spaces. We will work in a low regularity setting, where Strichartz estimates are necessary in addition to the standard Sobolev estimates. An interesting feature of this problem when compared to related works in the literature is that both of the spatial variables are restricted to the half-line. For this reason, a new approach is needed than the one previously used for the well-posedness of other initial-boundary value problems. An additional challenge is posed by the fact that the spatial domain (quarter-plane) has a corner at the origin, thus requiring one to expand the validity of certain Sobolev extension results to the case of a domain with a non-smooth (Lipschitz) and non-compact boundary. This is joint work with Turker Ozsari.

Transmission Problems in Planar Domains

Schedule: July 8 15:30-16:00 Room 823

Marius Mitrea

Baylor University, USA

Abstract:

In this talk, I will present recent advances in the analysis of transmission boundary value problems on rough domains, with data prescribed from within broad scales of function spaces. The central result provides a purely algebraic condition that fully characterizes when the problem is (Fredholm) solvable.

Maximal operators of Zygmund type

Schedule: July 8 14:30-15:00 Room 823

Laurent Moonens

Universite Paris Saclay, France

Co-Author(s): Galia Dafni, Emma D'Aniello, Giorgi Oniani

Abstract:

We will present recent results about maximal operators of Zygmund-type, i.e. of the form:

$$Mf(x) := \sup_{B \in \mathcal{B}(x)} \frac{1}{|B|} \int_B |f|,$$

where, for each x (in the n -th dimensional Euclidean space), $\mathcal{B}(x)$ is a collection of parallelepipeds parallel to the coordinate axes (or, more generally, of convex sets) containing, or being "close to" x . Depending on the geometry of sets in the collections $\mathcal{B}(x)$, one may wish to understand the optimal weak-type inequality M enjoys. The talk will detail a few famous cases, and provide some new results on this front. If time permits, we shall also discuss some issues related to their behavior in BMO or "moderated" BMO spaces.

On some singular integrals of Brascamp-Lieb type

Schedule: July 8 16:30-17:00 Room 823

Camil Muscalu

Cornell University, USA

Co-Author(s): Cristina Benea

Abstract:

The goal of the presentation is to describe some recent results obtained in joint work with Cristina Benea about some natural singular integrals of Brascamp-Lieb type.

What happens when bosons are mixed with fermions

Schedule: July 8 8:00-8:30 Room 823

Natasa Pavlovic

The University of Texas at Austin, USA

Co-Author(s): Esteban Cardenas, Joseph Miller, David Mitrouskas and Natasa Pavlovic

Abstract:

Investigating mixtures of bosons and fermions is an active area of research in experimental physics for constructing and understanding novel quantum bound states. These ultra-cold Bose-Fermi mixtures are intrinsically different from gases with only bosons or fermions. Namely, they show a fundamental instability due to energetic considerations coming from the Pauli exclusion principle. Inspired by this activity in the physics community, recently we started exploring the mathematical theory of Bose-Fermi mixtures. In particular, we will describe results obtained with Cardenas, Miller and Mitrouskas inspired by recent experiments by DeSalvo et al. on mixtures of light fermionic atoms and heavy bosonic atoms. These experiments reveal the emergence of an attractive fermion-mediated interaction between bosons, and as well as stability-instability transition. We give the first mathematical demonstration of this transition by studying the low-energy spectrum of a many-body interspecies Hamiltonian.

A Geometric Perspective on Poincaré-Sobolev Inequalities thru Harmonic Analysis and without derivatives

Schedule: July 8 17:30-18:00 Room 823

Carlos Perez Moreno

Ikerbasque at BCAM and University of The Basque Country, Spain

Co-Author(s): Iker Gardeazabal-Emiel Lorist and Alejandro Claros-Linfei Zheng

Abstract:

In this lecture, we present a modern perspective on function smoothness and regularity by employing sharp tools from Harmonic Analysis. The first part of the talk moves beyond classical pointwise analysis to explore functional smoothness through the lens of local averages. This approach provides a more flexible and robust framework for understanding analytical behavior, particularly in settings where traditional derivatives are not or cannot be considered. In the second part, we apply these harmonic analysis techniques to derive improved local Poincaré-Sobolev estimates, which are instrumental in proving the celebrated De Giorgi regularity theorem. This framework also provides a proof of the well known John-Nirenberg theorem for *BMO* functions. The central theme of the discussion will be the self-improving property, a remarkable phenomenon where modest local control over oscillations leads to significantly stronger global integrability. As another application, we present an extension of the celebrated Nash inequality (which yields another proof of De Giorgi's theorem), as well as an improved generalization of the Gagliardo-Nirenberg-Sobolev theorem using Campanato spaces.

Stein-Weiss type inequality in L^1 norm for vector fields and applications

Schedule: July 8 17:00-17:30 Room 823

Tiago Picon

University of Sao Paulo, Brazil

Abstract:

In this talk, we investigate the endpoint case $p = 1$ of the Stein-Weiss inequality for the Riesz potential. Our main result provides a characterization of this inequality for a special class of complex vector fields associated with cocanceling operators. As an application, we recover and extend several classical inequalities, and we also establish new solvability results for equations involving canceling and elliptic differential operators acting on measures. This work is based on joint research with Jorge Hounie (UFSCar, Brazil), Pablo De Napoli (Universidad de Buenos Aires, Argentina), Victor Biliatto (USP, Brazil), and Joel Coacalle (USP, Brazil)

The inhomogeneous six-wave kinetic equation

Schedule: July 8 14:00-14:30 Room 823

Luisa M Velasco

University of Texas at Austin, USA

Abstract:

Six-wave interactions arise in several physically relevant systems, including photon cascades in optical wave turbulence and Kelvin-wave interactions in superfluids in quantum wave turbulence. While four-wave interactions are typically dominant in systems of nonlinearly interacting waves, the resonant interactions corresponding to the dispersion relation $\omega = k^2$ are trivial in one dimension. As a result, these interactions do not appear in the statistical description of the one-dimensional system. In this setting, higher-order interactions must be considered, and the six-wave kinetic equation provides the relevant model. We initiate the analysis of the Cauchy problem for the spatially inhomogeneous six-wave kinetic equation, which is derived from the quintic nonlinear Schrodinger equation. More precisely, we prove the existence and uniqueness of nonnegative mild solutions. We also analyze their long-time behavior, proving scattering and bijectivity of the corresponding wave operators. This is joint work with N. Pavlovic and M. Taskovic.

Special Session 115 : Topology and Dynamics in Data

Organizer(s): Cerene Rathilal , Maria Vivien Visaya

Introduction: This special session will bring together researchers working at the intersection of topology and dynamical systems, with emphasis on both foundational approaches and practical applications. The session will explore how topological methods—including algebraic topology, shape theory, and persistent homology—contribute to the study of dynamical systems, whether deterministic or stochastic. Topics include topological dynamics, recurrence, and chaos, as well as applications to time-dependent data, physical systems, biological models, and computational frameworks. We also welcome contributions from Topological Data Analysis (TDA), both theoretical and applications, particularly (but not limited to) those addressing time series through computational topology. The session aims to promote cross-disciplinary discussion and demonstrate the relevance of topological methods in analysing and understanding dynamic behaviour in diverse contexts.

Temporal Graph Classification with Topological Machine Learning

Schedule: July 7 18:00-18:30 Room 740

Baris Coskunuzer

University of Texas at Dallas, USA

Co-Author(s): Md Joshem Uddin, Soham Changani

Abstract:

Temporal graph classification models time evolving networks in neuroscience, cybersecurity, and infrastructure. Existing temporal GNNs often miss global structural evolution and can be sensitive to noise and node permutations. In this talk, we present T3former, a topological machine learning framework that augments temporal graph models with stable global descriptors. T3former extracts spectral summaries and persistent homology features from each snapshot to capture multi scale dynamics such as connectivity changes and the emergence or disappearance of cycles. These signals are fused with temporal neural architectures to produce robust sequence level representations. Across real world datasets including brain, social, and traffic networks, T3former improves classification performance over strong TGNN baselines, especially when labels depend on structural dynamics.

Sheaf-Theoretic Models for Signal Interaction on Complex Networks

Schedule: July 7 17:30-18:00 Room 740

Chuan-Shen Hu

National University of Kaohsiung, Taiwan

Abstract:

Combinatorial structures such as graphs, simplicial complexes, and cell complexes provide the foundations for geometric and topological deep learning (GDL and TDL), yet the mechanisms governing how features propagate and interact across local and global structures during training remain not yet fully understood. In this talk, we present an ongoing project that develops a cellular sheaf-theoretic framework to study the consistency and interaction of learned signals on such mathematical objects. By encoding node features and edge weights as local sections of a cellular sheaf, the proposed approach enables a systematic analysis of local agreements and consistencies, providing a new perspective on feature diffusion and aggregation from a topological viewpoint. In addition, a multiscale extension inspired by topological data analysis is introduced to capture hierarchical feature interactions across different resolutions. This framework aims to provide a unified mathematical perspective on GDL/TDL models, with potential applications to tasks such as node classification, substructure detection, and community detection. This is a work in progress, and preliminary results have been presented at the AAAI 2026 Workshop on Foretell of Future AI from Mathematical Foundation.

Binding Closed Ties: Ensuring Topological Fidelity of Delay-Embedded Attractors via Redundant KNN Coverage

Schedule: July 7 17:00-17:30 Room 740

Paul Samuel Ignacio

University of the Philippines Baguio, Philippines

Co-Author(s): Jhunus Paul Viernes

Abstract:

Let (M, Φ^t) be a dynamical system on a compact manifold M , and let $x(t) = \Phi^t(x_0)$ denote a trajectory. Suppose that only a scalar observation $s(t)$ is available. For a fixed delay $\tau > 0$ and embedding dimension m , define the delay-coordinate map $F(t) = (s(t), s(t + \tau), \dots, s(t + (m - 1)\tau)) \in \mathbb{R}^m$, and let $X = \{F(t_i)\}_{i=1}^n \subset \mathbb{R}^m$ be a finite sample. Under standard embedding assumptions, X approximates a compact invariant set of the underlying dynamics up to smooth embedding. For $\varepsilon > 0$, let $\text{VR}_\varepsilon(X)$ denote the Vietoris--Rips complex of X , and let $\text{Dgm}_k(X)$ denote the persistence diagram in homological dimension k associated with the filtration $\{\text{VR}_\varepsilon(X)\}_{\varepsilon \geq 0}$. These diagrams provide a multiscale description of the topology of the sampled set X , capturing features such as connected components and 1-dimensional cycles. A major obstacle in this setting is computational: the size of $\text{VR}_\varepsilon(X)$ grows combinatorially with $|X|$, making persistent homology infeasible for large datasets. A common approach is to replace X by a smaller subset $L \subset X$, but arbitrary subsampling may result in substantial discrepancies between $\text{Dgm}_k(X)$ and $\text{Dgm}_k(L)$, as measured, for example, by the bottleneck distance d_B . In this work, we construct a subset $L \subset X$ by imposing coverage and overlap conditions on local neighborhoods. Fix $K \in \mathbb{N}$, and for each $x \in X$, let $\text{KNN}_K(x) \subset X$ denote the set of its K -nearest neighbors. We select $L \subset X$ such that $X \subset \bigcup_{\ell \in L} \text{KNN}_K(\ell)$, and such that there exists $r \in (0, 1]$ with the property that, whenever $\ell_i, \ell_j \in L$ satisfy $\text{KNN}_K(\ell_i) \cap \text{KNN}_K(\ell_j) \neq \emptyset$, their overlap obeys $|\text{KNN}_K(\ell_i) \cap \text{KNN}_K(\ell_j)| \geq rK$. The first condition ensures that every point of X is contained in at least one landmark neighborhood, while the second imposes a lower bound on the size of pairwise intersections among overlapping neighborhoods. These conditions induce a cover of X with controlled overlap, designed to preserve adjacency relations and cyclic configurations in the sampled data. In particular, they support preservation of homological features in dimensions H_0 , H_1 , and H_2 under subsampling, and thus reduce the discrepancy between $\text{Dgm}_k(X)$ and $\text{Dgm}_k(L)$ for $k = 0, 1, 2$. We evaluate the method on synthetic and real trajectory data by computing $d_B(\text{Dgm}_k(X), \text{Dgm}_k(L))$. We apply the proposed method in two case studies of time series data: delay-embedded electrocardiogram (ECG) signals and ocean drifter trajectories. In the ECG setting, delay-coordinate reconstruction yields point clouds for which we recover persistent 1-cycle features encoding periodicity information, whereas in the ocean drifter setting, sampled trajectories give rise to point clouds whose topological features reflect coherent transport structures in fluid flow. In both cases, controlling the discrepancy between persistence diagrams provides a quantitative mechanism for preserving the topological signatures used in data-driven analysis of the underlying dynamics while significantly reducing computational cost.

On Mapper - a TDA approach to visualising data

Schedule: July 7 18:30-19:00 Room 740

Cerene Rathilal

University of KwaZulu-Natal (South Africa), So Africa

Co-Author(s): Maria Vivien Visaya

Abstract:

Topological Data Analysis (TDA) is a modern approach for analysing complex datasets using tools from algebraic topology, the branch of mathematics concerned with studying the shape of spaces. Unlike conventional statistics, which often assumes linear or low-dimensional structures, TDA is designed to uncover hidden patterns and global organisation in high-dimensional and noisy data. There are two main approaches to TDA: Persistent Homology (PH) and Mapper. In this talk, we will focus on Mapper, which creates a simplified graph-based representation of high-dimensional data. It works by partitioning the dataset, analysing local structures, and connecting them into a network called a Mapper graph. We end by discussing an application for breast cancer analysis.

Topological signatures of admixture in genomic data

Schedule: July 7 16:30-17:00 Room 740

Maria Vivien Visaya

University of Johannesburg, So Africa

Co-Author(s): Al Bien Aculan, Rachele Sambayan, Victoria Mendoza, Ricardo del Rosario

Abstract:

We investigate topological summaries of high-dimensional genomic data to detect and characterise population admixture, without relying on parametric population genetic models. Using persistent homology, we analyse haplotype data from 26 human populations (3202 individuals) from the 1000 Genomes Project. Admixed populations exhibit distinct and reproducible topological signatures, particularly in the distribution and persistence of one-dimensional homology classes. Unlike non-admixed populations, where short-lived cycles emerge only at large filtration scales, admixed populations display cycles distributed across a broad range of scales, reflecting heterogeneous ancestry structure. We formalise this observation through a non-admixture score (NAS) derived from persistence barcode statistics, which robustly separates admixed from non-admixed populations across genome-wide and per-chromosome analyses. Further, by equipping persistence diagrams with the Wasserstein metric, we demonstrate that hierarchical clustering recovers groups of populations with shared admixture signatures, revealing structure not captured by classical measures such as F_{ST} . Our results suggest that persistent homology provides an orthogonal, model-free framework for population genetic inference, capturing geometric and topological aspects of genetic variation that complement existing statistical approaches. This positions topological data analysis as a promising tool for studying complex evolutionary processes in large-scale genomic data.

Special Session 116 : Partial Differential Equations with Applications in Biology

Organizer(s): King Yeung Lam , Yuan Lou , Idriss Mazari-Fouquer

Introduction: This special session brings together active researchers working at the interface of partial differential equations and the life sciences. PDEs are ubiquitous in capturing the spatial and temporal dynamics of complex biological phenomena, including processes such as pattern formation, population dispersal, ecological invasions, spread of infectious disease, intracellular chemotactic signaling. The session features a diverse group of speakers whose work spans theoretical analysis, numerical simulations, and biologically informed modeling. Collectively, the talks will highlight new mathematical challenges and biological insights arising from recent works and foster discussion and collaboration across different expertise.

On Models of Shared Resource Competition, Coexistence, Stability and Traveling Waves

Schedule: July 8 9:30-10:00 Room 425

Wei Feng

University of North Carolina Wilmington, USA

Co-Author(s): Xin Lu, Karen Ward

Abstract:

We investigate reaction-diffusion models for two competing species exploiting a common standing resource. The dynamics are governed by a system of nonlinear differential equations admitting three equilibrium classes: extinction, competitive exclusion, and coexistence. Analytical conditions on the biological parameters ensuring the presence and asymptotic stability of these equilibria are derived, with particular emphasis on the coexistence equilibrium. When the level of available resources R remains constant over an unbounded spatial domain, we further examine the global stability of the coexistence equilibrium via traveling wavefronts. Using the upper-lower solution method, we establish the existence of traveling wave solutions connecting the extinction or single-dominance states to the coexistence state for a continuum of wave speeds exceeding a biologically determined minimal value. If the level of available resources R varies in space or time but remains bounded, the obtained results may be extended to provide insights into the spatially dependent coexistence state and permanence effect of the ecological system. Numerical simulations are provided to corroborate theoretical results and to illustrate dynamic transitions from extinction or single-dominance to stable coexistence.

An abstract framework for a class of nonlocal structured population models: existence, uniqueness and stability of steady states

Schedule: July 8 14:30-15:00 Room 425

Leo Girardin

CNRS, France

Co-Author(s): Jerome Coville

Abstract:

This talk is concerned with the study of a class of nonlinear nonlocal functional evolution problems defined in an abstract Banach algebra. We introduce an abstract functional setting that encompasses a wide range of structured population models appearing in biomathematical literature. Within this framework, we analyze the well-posedness of the Cauchy problem and the existence of stationary solutions in the positive cone of the Banach algebra. By reviewing a large number of approaches, we also derive conditions for the local and global stability of these stationary solutions. Additionally, we explore the limits of these conditions by exhibiting explicit counterexamples. In particular, for mutation--selection models with symmetric mutation operators, we uncover both sufficient conditions for existence, uniqueness and stability, and counterexamples to existence or stability.

Continuous and Discontinuous Traveling Waves in a Hyperbolic Keller-Segel Equation

Schedule: July 8 9:00-9:30 Room 425

Quentin GRIETTE

LMAH, University of Le Havre Normandy, France

Abstract:

We describe a hyperbolic model with cell-cell repulsion with a dynamics in the population of cells. More precisely, we consider a population of cells producing a field (which we call pressure) which induces a motion of the cells following the opposite of the gradient. The field indicates the local density of population and we assume that cells try to avoid crowded areas and prefer locally empty spaces which are far away from the carrying capacity. We describe the traveling wave solutions for this equation and in particular the sharp traveling waves that are identically zero after some point in space; we show that these waves are necessarily discontinuous and give and estimate of their speed. We also construct continuous traveling waves which have a speed that is strictly greater than the one of the sharp waves. Finally, we investigate the behavior of a related model with diffusion and show that the behavior of the vanishing viscosity solutions is consistent with the limit equation.

Personalized Spatiotemporal Radiotherapy for GBM: A PDE-Constrained Optimization Study

Schedule: July 8 8:00-8:30 Room 425

Chiu-Yen Kao

Claremont McKenna College, USA

Co-Author(s): Chiu-Yen Kao, Seyyed Abbas Mohammadi, and Mohsen Yousefnezhad

Abstract:

We develop a personalized optimization framework for designing spatio-temporal radiotherapy strategies for Glioblastoma Multiforme (GBM). The tumor dynamics are described by a reaction-diffusion model on patient-specific brain geometries, and the treatment objective is formulated as a PDE-constrained optimization problem in which the admissible targeting region is allowed to vary on each day of therapy. The resulting optimization requires repeated solutions of the state and adjoint equations, and we implement an adjoint-driven gradient algorithm with line search and projection to enforce clinical dose constraints. To improve robustness, the algorithm is first validated on a simplified surrogate model before being applied to full patient data. The proposed framework generates patient-specific targeting volumes informed by clinical and radiological parameters, producing a dynamic treatment region that adapts to tumor evolution rather than relying on standard fixed or population-based margins. Our results demonstrate that incorporating daily adaptability into the optimization process can lead to substantially different and potentially more effective treatment targets. This study highlights the potential of PDE-constrained optimization as a mathematical tool for personalized radiotherapy planning.

On principal eigenvalues for elliptic operators with divergence-free drifts

Schedule: July 8 15:30-16:00 Room 425

Shuang Liu

Beijing Institute of Technology, Peoples Rep of China

Co-Author(s): Yuan Lou

Abstract:

In this talk, we will discuss some progress on principal eigenvalues of second order elliptic operators with the divergence-free drifts. Some monotonicity and asymptotic behaviors of principal eigenvalues, with respect to diffusion rate and flow amplitude, are established. These local asymptotic analysis can help us find some global information on the principal eigenvalue, which enables us to better understand qualitative properties of the principal eigenvalues. This is a joint work with Professor Yuan Lou.

Recovering Model Parameters from Boundaries and Turing Patterns: An Inverse Problems Approach to PDEs in Mathematical Biology

Schedule: July 8 14:00-14:30 Room 425

Catharine W Lo

Shenzhen University, Peoples Rep of China

Co-Author(s): Ming-Hui Ding, Yuhan Li, Hongyu Liu

Abstract:

In this talk, we present a unified inverse problem framework for identifying unknown parameters and functional forms in biological PDE models using boundary, averaged, and spatial pattern data. We showcase a series of results, including boundary-driven recovery in local and nonlocal predator-prey, aggregation, and chemotaxis systems, as well as amplitude-based reconstruction from Turing patterns. Applications span across tumor-immune interactions, ecological dispersal, infectious disease modeling, cell microrheology, and microbial chemotaxis. We emphasize how diverse measurement setups -- such as boundary fluxes, time-averaged outputs, and spatial amplitudes -- enable unique and robust parameter identification across multiple biological scales. Our work bridges rigorous analytical PDE theory with realistic biological constraints, providing a principled methodology to infer mechanistic models from observed dynamics in ecology, immunology, developmental biology, and epidemiology.

PDE models for the growth of heterogeneous cell populations: travelling fronts, sharp interfaces, and concentration phenomena

Schedule: July 8 8:30-9:00 Room 425

Tommaso Lorenzi

Politecnico di Torino, Italy

Abstract:

In this talk, PDE models for the growth of heterogeneous cell populations will be considered. Both models with discrete phenotype states, which consist of coupled systems of nonlinear PDEs, and models wherein the phenotype enters as a continuous structuring variable, which are formulated as non-local PDEs, will be examined. Focusing on scenarios where cells with different phenotypes are spatially segregated across invading fronts, travelling wave solutions that exhibit sharp interfaces, for the first class of models, and concentration phenomena, for the second class of models, will be studied.

Pattern formation in two-component reaction-diffusion systems with equal diffusion coefficients

Schedule: July 8 13:30-14:00 Room 425

Hirokazu Ninomiya

Meiji University, Japan

Abstract:

In general, whether Turing instability can occur when the diffusion coefficients are equal is an important problem in pattern formation. Classical Turing instability requires different diffusion rates, and when the diffusion coefficients are equal, linear stability analysis predicts that the homogeneous equilibrium is stable. Nevertheless, instability may arise beyond the linear framework. In [Ninomiya: JDE 392 (2024) 255-265], an example was constructed in which the kinetic system has an asymptotically stable equilibrium, while the corresponding reaction-diffusion system admits unstable stationary solutions arbitrarily close to the homogeneous equilibrium. In this talk, we generalize this example and derive conditions on the homogeneous nonlinear terms under which such phenomena occur.

A piston to counteract diffusion: The influence of an inward-shifting boundary on the heat equation in half-space

Schedule: July 8 17:00-17:30 Room 425

Samuel ST Treton

University of Nantes, France

Co-Author(s): Mingmin Zhang

Abstract:

Climate change, among other environmental factors, has an increasing impact on the distribution of biological populations. To better understand how these populations respond to dynamic external pressures, we propose a new diffusion model in the moving half-line $\Omega_t := z > b(t)$, where the boundary position $b(t)$ is a given, smooth and increasing function of time. By imposing a suitable (Robin-type) boundary condition at $z = b(t)$, we prevent individuals from leaving the domain, so that the shifting boundary acts as an impermeable wall---a piston---that sweeps the individuals it encounters. This framework leads to an intricate interplay between the diffusion mechanism (which tends to spread the population) and the accumulation of individuals against the boundary. As it is natural to consider algebraic speeds for the boundary, we focus here on cases where $b(t) \sim ct^\beta$ as $t \rightarrow \infty$. Our main contribution is a complete characterization of the long-time distribution of the population for any $\beta \in [0, 1]$. Notably, the asymptotic solution switches from a Gaussian shape to an exponential shape at $\beta = 1/2$, and converges to a nontrivial steady state in the special case $\beta = 1$. In this latter scenario, the dispersal effect of the Laplacian is perfectly balanced by the accumulation of individuals at the moving boundary.

Dynamics of a consumer-resource model: persistence, extinction and blowup

Schedule: July 8 16:30-17:00 Room 425

Zhian Wang

The Hong Kong Polytechnic University, Hong Kong

Abstract:

This talk aims to discuss a novel consumer-resource system, which incorporates resource decay and consumer loss as well as the resource diffusion, under conditions that the resource input rate may exhibit spatial heterogeneity and temporal periodicity. Our findings show two sharply contrasting dynamical regimes: (i) for the immobile resource case, the resource remains limited at locations where it decays, while exhibits infinite-time blow-up at locations where it does not decay either when the consumer population becomes extinct, or for the high yield rates when the consumer population persists; (ii) in contrast, a mobile resource remains globally bounded for all time unconditionally. These results highlight the pivotal role of the resource decay and motility in suppressing blow-up phenomena, thereby offering a new understanding for the consumer-resource interaction in real ecological systems.

Propagation direction of bistable pulsating waves for population models in discrete periodic habitat

Schedule: July 8 17:30-18:00 Room 425

Xiao Yu

South China Normal University, Peoples Rep of China

Abstract:

How does spatio-temporal heterogeneity influence the propagation direction of bistable waves? To explore this question we formulate a nonlocal and time-delay population model with directional dispersal in discrete periodic habitat. Within a bistability framework, we determine the speed sign of bistable pulsating wave, followed by the existence and uniqueness of the pulsating wave. It turns out that time delay does not influence the sign but spatial heterogeneity does. Furthermore, dispersal strategies that ensure propagation success are shown to exist.

Analytical and Numerical Perspectives on Necrotic Tumor Growth via Obstacle Problems

Schedule: July 8 15:00-15:30 Room 425

Zhennan Zhou

Westlake University, Peoples Rep of China

Abstract:

Mechanical-based tumor growth models derived from the incompressible limit face significant challenges in capturing the emergence of a necrotic core. This talk presents a unified free boundary model that resolves this by formulating the internal pressure as an obstacle problem, where the necrotic core is naturally defined as the coincidence set. First, we will establish the analytical foundations of this model, detailing semi-analytical solutions that quantify transitional phases of necrotic core development and proving the existence of traveling wave solutions that incorporate non-zero outer cell densities. Second, we will address the fundamental numerical challenge of simulating this system: the inner necrotic interface lacks the explicit advection structure seen on the outer boundary. To overcome this, we introduce a stabilized predictor-corrector strategy coupled with Boundary Integral (BI) and Kernel-Free Boundary Integral (KFBI) solvers on Cartesian grids. Together, these analytical and numerical frameworks allow us to accurately capture complex geometric evolution and the topological transitions of necrotic core nucleation.

Special Session 117 : Patterns and Attractors in Nonlinear Dynamics

Organizer(s): Jia-Yuan Dai , Phillipo Lappicy , Junsik Bae

Introduction: This session brings together recent advances in nonlinear dynamical systems generated by ordinary, partial, stochastic and delay differential equations. The talks explore a wide spectrum of topics, including symmetries, stability and blow-up phenomena, pattern formation, bifurcation analysis, global attractors, and control. The methods discussed range from topological and analytical techniques to cutting-edge computer-assisted proofs. The session aims to promote dialogue and collaboration across different areas of dynamical systems, encouraging the exchange of ideas at the interface of theory and real-world applications.

Traveling waves in the reaction-diffusion equation with discontinuity

Schedule: July 7 8:00-8:30 Room 426

Junsik Bae

Kyungpook National University, Korea

Co-Author(s): Wonhyung Choi, Yong-Jung Kim

Abstract:

We classify traveling waves and stationary solutions of a reaction-diffusion equation arising in population dynamics with Allee-type effects. The reaction term is given by a quadratic polynomial with a discontinuity at zero, which captures finite-time extinction for sub-threshold populations. This discontinuity induces a free boundary in the wave profile, a phenomenon that distinguishes the model from the classical logistic or Allen-Cahn equations. A complete scenario is presented that connects monostable and bistable traveling waves through the wave speed parameter. This is a joint work with Wonhyung Choi (Hankyong National Univ.) and Yong-Jung Kim (KAIST).

Asymptotic behavior for the incompressible Navier-Stokes system revisited

Schedule: July 7 14:30-15:00 Room 426

Noboru Chikami

Nagoya Institute of Technology, Japan

Abstract:

We study the asymptotic behavior of small global solutions to the incompressible Navier-Stokes system. It is known that a suitable spatial decay allows the global solution to behave like self-similar solutions as time goes to infinity (Kato(1984), Planchon(1998)). More precisely, if the spatial decay of the initial data is critical (i.e., $\varphi(x) = O(|x|^{-1})$) then the solution is asymptotic to a nonlinear self-similar solution, and if not, then the solution is asymptotic to a linear self-similar solution. Under minimal assumptions on the initial data, we revisit this classical result on asymptotically self-similar solutions, and derive the second asymptotic expansion. The result can be extended to multiplier-type weighted Lorentz spaces.

Transition Routes to Synchronization in the Classical Kuramoto Model

Schedule: July 6 15:30-16:00 Room 426

Jia-Yuan Dai

National Tsing Hua University, Taiwan

Co-Author(s): Bernold Fiedler, Alejandro L'opez Nieto

Abstract:

Most forward orbits of the classical Kuramoto model with identical frequencies lead to stable totally synchronized states. Besides, there is a plethora of saddle partially synchronized states. In this talk, we rigorously describe the transition routes from partial synchronization to total synchronization. By the gradient structure of the classical Kuramoto model, the global attractor consists of (circles of) equilibria and heteroclinic orbits between them. By using the permutation symmetry of indices, we determine when two distinct equilibria can be connected by heteroclinic orbits. This yields a connection graph ordered by inclusion. Moreover, we show that, surprisingly, the invariant manifolds of partially synchronized equilibria are linear. As a consequence, the classical Kuramoto model is structurally stable Morse-Smale system. In particular, the connection graph persists under any small perturbations of the classical model. This is joint work with Bernold Fiedler and Alejandro L'opez Nieto.

Detecting and quantifying random bifurcations in collapsing attractors

Schedule: July 6 14:00-14:30 Room 426

Maximilian Engel

University of Amsterdam, Netherlands

Co-Author(s): Alexandra Blessing, Alex Blumenthal, Maxime Breden

Abstract:

In many situations, deterministic dynamical systems may exhibit non-trivial attractors which collapse to a random point under the addition of Gaussian noise. This phenomenon is widely known as synchronization by noise and seems to make bifurcations of attractors to higher-dimensional objects disappear in the stochastic case. This point of view was first challenged by Callaway et al. 2017 with respect to the pitchfork bifurcation in the presence of additive noise, showing a transition from uniform to non-uniform synchronization mirroring the original bifurcation. In this talk, I will give a summary on results from co-authors and myself that have extended these observations to multiple and infinite dimensions and have provided a quantitative analysis via large deviation estimates for finite-time Lyapunov exponents. I will also mention current efforts to fully transfer this framework to SPDEs.

L^2 -contraction of viscous-dispersive shocks for KdV-Burgers equation

Schedule: July 7 8:30-9:00 Room 426

Namhyun NE Eun

Korea Institute for Advanced Study, Korea

Co-Author(s): Geng Chen, Moon-Jin Kang, Yannan Shen

Abstract:

The Korteweg--de Vries--Burgers (KdVB) equation is a fundamental model capturing the interplay of nonlinearity, viscosity (dissipation), and dispersion, with broad physical relevance. It is well known that the KdVB equation admits traveling wave solutions, called viscous-dispersive shocks. These shock profiles are monotone in the viscosity-dominant regime, while they exhibit infinitely many oscillation when dispersion dominates. In this talk, we study the stability of such viscous-dispersive shocks, focusing on an L^2 -contraction property under arbitrarily large perturbations, up to a time-dependent shift. We begin with viscous shocks of the viscous Burgers equation (i.e., the KdVB equation without dispersion), then treat monotone viscous-dispersive shocks and finally address oscillatory shocks. We also present detailed structural properties of the oscillatory profiles. This is joint work with Geng Chen (University of Kansas), Moon-Jin Kang (KAIST), and Yannan Shen (University of Kansas).

Time-asymptotic stability of composite waves for compressible Navier-Stokes-Korteweg and Navier-Stokes-Fourier-Korteweg systems

Schedule: July 7 9:30-10:00 Room 426

Sungho Han

KAIST, Korea

Co-Author(s): Jeongho Kim and Moon-Jin Kang

Abstract:

In this talk, we discuss the long-time behavior of one-dimensional compressible fluids with internal capillarity. For the barotropic Navier-Stokes-Korteweg system, we establish the time-asymptotic stability of a composite wave consisting of a rarefaction wave and a shifted viscous-dispersive shock. Furthermore, we extend this framework to the non-barotropic Navier-Stokes-Fourier-Korteweg system to prove the stability of composite waves involving a rarefaction wave, a viscous contact wave, and a shifted viscous-dispersive shock. Our analysis is based on the method of a -contraction with shifts, which combines weighted relative entropy estimates with dynamical shifts applied to the shock profiles. These results are based on joint works with Jeongho Kim and Moon-Jin Kang.

Stable Blow-up Profiles in Transport-Type Equations

Schedule: July 6 17:30-18:00 Room 426

Bongsuk Kwon

Ulsan National Institute of Science and Technology, Korea

Co-Author(s): Yunjoo Kim, Wanyong Shim

Abstract:

We investigate C^1 blow-up phenomena for a class of transport-type equations. The classical method of characteristics provides only limited information on singularity formation, typically capturing the temporal blow-up rate along characteristic curves. While this approach has been successfully applied to the Burgers equation and various models of wave breaking in water waves, it does not fully describe the structure of singularities. It is well known that singularities in the Burgers equation exhibit $C^{1/3}$ regularity, a feature also observed in certain fluid models such as the Euler equations. This has led to the common belief that all C^1 blow-up solutions arising in transport equations share the same regularity profile. In this work, we show that this paradigm is incomplete. We construct self-similar blow-up profiles for a general class of transport-type equations-often arising as leading-order models in water wave dynamics-that exhibit singular behaviors distinct from those of the Burgers equation. In particular, these profiles may possess different Hölder regularities. Our framework applies to several important models, including the Camassa-Holm equation, the Hunter-Saxton equation, and the b -family of fluid transport equations. We present the construction of explicit stable blow-up profiles and outline the proof of their stability in a suitable functional setting. This yields sharp regularity results and a refined description of blow-up dynamics. If time permits, we will also discuss more exotic self-similar blow-up profiles arising within a broader scaling framework.

Sharp interfaces in singular reaction diffusion systems

Schedule: July 6 15:00-15:30 Room 426

Tommaso Lamma

Leiden University, Netherlands

Co-Author(s): Arjen Doelman, Frits Veerman, Paul Carter

Abstract:

There are systems of reaction diffusion equations in which the interplay of bistability and spatial scale separation leads to the emergence of sharp interfaces separating two asymptotic homogeneous states. Multiple sharp interfaces interact and in some cases evolve into a stationary multi-front pattern, a derivation of interaction equations will be presented as a dimensionality reduction procedure.

The dynamics of global attractors for fully nonlinear parabolic equations in 1d

Schedule: July 6 13:30-14:00 Room 426

Phillipo Lappicy

Universidad Complutense de Madrid, Spain

Abstract:

We explicitly construct global attractors for fully nonlinear parabolic equations in one spatial dimension with two types of phenomena. First, in case the semiflow is dissipative, the attractor is compact and it can be decomposed as equilibria and heteroclinic orbits. Second, in case the semiflow is not dissipative, there are blow-up solutions and the attractor is unbounded - which can be compactified using an appropriate Poincaré projection with an induced flow at infinity. In this setting, we view blow-up solutions as heteroclinic orbits to infinity. In both cases of dissipative and non-dissipative nonlinearities, we state necessary and sufficient conditions for the occurrence of heteroclinics between hyperbolic equilibria. The prototype examples are a bounded and unbounded version of the Chafee-Infante attractor.

Time-asymptotic behavior of solutions to the 3D Barotropic Navier-Stokes equations toward viscous shock in outflow problems

Schedule: July 7 13:30-14:00 Room 426

Hobin Lee

Korea Advanced Institute of Science and Technology, Korea

Co-Author(s): Hyeonseop Kim, Moon-Jin Kang

Abstract:

We study an initial-boundary value problem for the 3D barotropic Navier-Stokes equations. More specifically, we consider the outflow problem on the spatial domain $\mathbb{R}_+ \times \mathbb{T}^2$, where the far-field condition is given by two different constant states. In this paper, our main result is the orbital stability of the viscous shock wave in the subsonic case, assuming that both the shock amplitude and the initial perturbation are small. The core of our proof consists of two main steps: obtaining a priori zeroth-order estimates and higher-order estimates. In the first step, we utilize the method of a -contraction with shifts, originally introduced by Kang and Vasseur in 2017, which is highly effective for controlling the effects of the viscous shock. In the second step, we employ the classical energy method to derive sharp estimates for controlling the boundary terms.

On the optimal rate of vortex stretching for axisymmetric Euler flows without swirl

Schedule: July 7 15:30-16:00 Room 426

Deokwoo Lim

Korea Institute for Advanced Study, Korea

Co-Author(s): Deokwoo Lim and In-Jee Jeong

Abstract:

We consider incompressible Euler flows with axisymmetry and without swirl. In $\mathbb{R}^3$, we prove the $t^{4/3}$ -upper bound for the growth of the vorticity maximum. This was conjectured by Childress (Phys. D, 2008) and supported by numerical computations from Childress--Gilbert--Valiant (J. Fluid Mech., 2016). The key idea is to estimate the velocity maximum by the kinetic energy and conserved quantities related to the vorticity. This is a joint work with In-Jee Jeong (SNU).

Nonautonomous differential equations in the presence of bounded noise

Schedule: July 6 14:30-15:00 Room 426

Iacopo P. Longo

University of Exeter, England

Co-Author(s): Konstantinos Kourliouros, Martin Rasmussen

Abstract:

Nonautonomous systems subject to noise arise naturally in many applied contexts. Particularly relevant are those featuring time-dependent parameters and uncertainties, which may drive the emergence of tipping points. In this talk, we focus on the case of bounded noise, where the dynamics can be captured topologically via deterministic set-valued dynamical systems: initial conditions are evolved under all admissible noise realisations, abstracting from probabilistic details. However, as these systems operate on the space of nonempty compact subsets---a space lacking Banach structure---they pose substantial analytical and numerical challenges. In particular, bifurcation analysis of attractors remains a significant obstacle. To address this, we derive a higher-dimensional single-valued deterministic dynamical system which characterizes the evolution of the boundary of invariant sets (typically attractors) of certain differential inclusions.

Uniqueness and weak-BV stability for the isentropic Euler system: inflow and outflow problems

Schedule: July 7 9:00-9:30 Room 426

HyeonSeop Oh

Korea Advanced Institute of Science and Technology, Korea

Co-Author(s): Moon-Jin Kang, Jiayun Meng, and Alexis Vasseur

Abstract:

In this talk, we consider initial-boundary value problems for the one-dimensional isentropic Euler system in the half-space, focusing on both inflow and outflow problems. We prove that small BV solutions in the subsonic region are unique and stable within a wild class of weak solutions satisfying the so-called strong trace property. In particular, we establish quantitative Hölder-type stability estimates in the L^2 norm. While the small BV solutions, being in the subsonic region, are associated with non-characteristic boundaries, the wild solutions admit characteristic boundaries. Our analysis is based on the method of α -contraction with shifts, although the stability results do not depend on the shift. This talk is based on a joint work with Moon-Jin Kang, Jiayun Meng, and Alexis Vasseur.

Stability of Multidimensional Periodic Waves of Parabolic Systems

Schedule: July 7 14:00-14:30 Room 426

Luis Miguel Rodrigues

Univ Rennes, France

Co-Author(s): Benjamin Melinand (Strasbourg, France), Aric Wheeler (Duke, USA).

Abstract:

We discuss a few steps towards a complete stability theory for genuinely multidimensional periodic traveling waves of parabolic systems. On the one hand for large classes of parabolic systems we prove that spectral stability implies nonlinear asymptotic stability in a suitable sense. On the other hand, for two-dimensional reaction-diffusion systems we provide large-time asymptotics in terms of solutions to averaged, modulation systems. Thus, for such systems, we extend the comprehensive theory now available for plane periodic waves to the multidimensional context. Concerning the latter, a significant part of the analysis is devoted to obtaining new results on near-constant anisotropic dynamics, to be applied to the averaged systems and including dispersive-diffusive estimates and derivations of artificial viscosity systems.

Stability of shock profiles for the Navier-Stokes-Poisson system

Schedule: July 6 18:00-18:30 Room 426

Wanyong Shim

Korea Advanced Institute of Science and Technology, Korea

Abstract:

We consider the one-dimensional Navier--Stokes--Poisson (NSP) system, which describes the dynamics of positive ions in a collision-dominated plasma. The NSP system admits a one-parameter family of smooth traveling wave solutions, known as shock profiles. In this talk, we study the stability of these shock profiles. Our analysis is based on the pointwise semigroup method, which combines spectral analysis with Green's function estimates. We first establish the spectral stability of the shock profiles. Building upon this, we derive pointwise bounds on the Green's function for the associated linearized problem, which yield linear and nonlinear asymptotic orbital stability.

Double Beltrami States in Hall magneto-hydrodynamics

Schedule: July 7 15:00-15:30 Room 426

Jaeyong Shin

Yonsei University, Korea

Co-Author(s): Hantaek Bae, Kyungkeun Kang

Abstract:

In this talk, we investigate double Beltrami states in the Hall magneto-hydrodynamic (Hall MHD) equations. Initially, we examine the double Beltrami states as a special class of steady solutions to the ideal Hall MHD equations, which are closely related to Beltrami flows in incompressible fluid dynamics. Specifically, we classify the double Beltrami states and show that they can be derived by using the variational method as energy minimizers, subject to the conservation of two helicities. We then extend our analysis to time-dependent double Beltrami states in the viscous and resistive Hall MHD equations, exploring their exact form and stability properties.

Vortex atmospheres of traveling vortices: rigorous definition, existence, and topological classification

Schedule: July 6 18:30-19:00 Room 426

Young-Jin Sim

KIAS, Korea

Co-Author(s): Kyudong Choi, In-Jee Jeong, Young-Jin Sim

Abstract:

In incompressible and inviscid fluids, the vortex atmosphere refers to the collection of fluid particles outside the support of a traveling vortex that are nevertheless carried along with it. This phenomenon has been recognized since the nineteenth century, e.g., in the classical works of O. Reynolds [Nature, 1876] and O. Lodge [Lond. Edinb. Dubl. Phil. Mag., 1885], yet rigorous mathematical definitions and proofs have remained largely undeveloped, with most subsequent studies relying on thin-core approximations or asymptotic analyses. In this talk, we give a rigorous definition of a vortex atmosphere and establish its existence and uniqueness. We further compare the planar atmosphere surrounding a 2D vortex dipole with the axisymmetric atmosphere surrounding a 3D vortex ring. In particular, we emphasize and prove the topological distinctions observed by W. Hicks [Lond. Edinb. Dubl. Phil. Mag., 1919]: under natural assumptions, every 2D dipole with its atmosphere forms an oval-shaped region, whereas for 3D rings, both spheroidal and toroidal configurations may occur. Our proof is based on showing that each atmosphere can be characterized precisely as a specific superlevel set of its corresponding stream function.

High-Voltage Ionized Gas with Spherical Cathode Emission

Schedule: July 6 17:00-17:30 Room 426

Masahiro Suzuki

Nagoya Institute of Technology, Japan

Abstract:

We consider a plasma that is created by a high voltage difference, which is known as a Townsend gas discharge. The plasma is confined to the region between two concentric spheres, one of which is a cathode and the other an anode. Ion-electron pairs are created by collisions inside the plasma. Additional electrons enter the plasma by collisions of ions with the cathode. We prove under certain conditions that there are many steady states exhibiting gas discharge, beginning with a 'sparking' voltage. In fact, there is an analytic one-parameter family of them that connects the non-ionized gas to a plasma with arbitrarily high ionization or arbitrarily high potential, or else the family ends at an 'anti-sparking' voltage. This talk is based on a joint work with Professor W. A. Strauss (Brown Univ.).

Patterns in miscible displacement in porous media

Schedule: July 6 16:30-17:00 Room 426

Sergey Tikhomirov

Pontificia Universidade Catolica do Rio de Janeiro - PUC-Rio, Brazil

Co-Author(s): Yu. Petrova, Ya. Efendiev

Abstract:

We study the motion of miscible liquids in porous media. Injection of a less viscous fluid into a more viscous one produces an instability known as viscous fingering. This phenomenon is described by a multidimensional PDE system consisting of mass conservation, incompressibility, and Darcy law. In heterogeneous media, the displacement pattern forms a regular structure. In homogeneous media, it is more chaotic, and displays an intriguing regime of intermediate concentration. To improve estimates for the mixing-zone size, we study a related model of gravity-driven fingering based on the incompressible porous media equation with diffusion. We represent the medium as a system of vertical tubes. For the simplest case of 2 tubes we were able to find cascades of travelling waves [1]. For the case of infinitely many tubes we demonstrate the existence of an infinite cascade of travelling waves. Speed of travelling waves could be interpreted as speed of viscous fingers and back front propagation. The result in the simplified model suggests that existing estimates for original multi-dimensional problems could be improved. [1] Petrova Yu., Tikhomirov S., Efendiev Ya. Propagating terrace in a two-tubes model of gravitational fingering. SIAM Journal on Mathematical Analysis, 57 (2025), 30-64.

Special Session 118 : Nonlinear Wave systems: Analysis and Computation

Organizer(s): Vahagn Manukian , Stathis Charalampidis , Stéphane Lafortune

Introduction: The presenters in this special session will share recent advances in the understanding of pattern formation in both one and multiple dimensions. They will discuss the mechanisms driving pattern formation in nonlinear complex systems, as well as the existence, stability, and dynamic behavior of simple and complex patterns. These developments have been achieved through cutting-edge analytical and numerical methods.

High Order Mimetic Difference Methods and Applications

Schedule: July 9 17:30-18:00 Room 825

Jose E Castillo

Computational Science Research Center at San Diego State University, USA

Abstract:

Mimetic difference operators have been used more and more frequently to construct numerical schemes for solving partial differential equations with variable degree of success. There are many researches currently active in this area pursuing different approaches to achieve this goal and many algorithms have been developed along these lines. Loosely speaking, mimetic methods have discrete structures that mimic vector calculus identities and theorems. These make the numerical schemes based on mimetic difference operators more faithful to the physics of the problem under investigation. Specific approaches to discretization have achieved this compatibility following different paths, and with diverse degrees of generality in relation to the problems solved and the order of accuracy obtainable. In this session advances of High Order Mimetic differences methods and applications will be presented.

Pattern formation near a Turing-fold bifurcation: tipping evasion, quasi-periodicity & chaos

Schedule: July 9 16:30-17:00 Room 825

Arjen Doelman

Leiden University, Netherlands

Co-Author(s): Dock Staal (Leiden University) & Todd Kapitula (Calvin College)

Abstract:

Recent simulations of ecosystem models (of reaction-diffusion type) have shown that a Turing bifurcation preceding a saddle-node bifurcation may enable an ecosystem to evade tipping: under slowly changing circumstances, an ecosystem may form patterns instead of collapsing into a less desirable state. Thus, the formation of patterns may increase the resilience of the ecosystem. In this talk we present the system of coupled modulation equations that governs the dynamics of small amplitude patterns near a co-dimension 2 Turing-fold bifurcation. First we show that there is a critical coefficient -- that can be determined explicitly and that corresponds to the Landau coefficient in the classical (co-dimension 1) Ginzburg-Landau setting -- that decides whether the system tips or evades tipping by forming (stable) patterns. Moreover, we show that the boundary of the region in (wavenumber, parameter)-space of stable periodic solutions -- i.e. the Busse balloon -- is much richer than that in the classical Ginzburg-Landau case. Instead of only a sideband instability, patterns can also be destabilized by several Turing- and Turing-Hopf-type mechanisms. The associated bifurcations may first lead to the formation of stable stationary quasi-periodic patterns and subsequently to time-periodic and eventually irregular dynamics.

On the proximal dynamics between integrable and non-integrable members of a generalized Korteweg-de Vries family of equations

Schedule: July 9 17:00-17:30 Room 825

Nikos I Karachalios

Department of Mathematics, University of Thessaly, Greece

Co-Author(s): Dionyssios Mantzavinos and Jeffrey Oregero

Abstract:

We discuss current results concerning the distance between solutions to the integrable Korteweg-de Vries (KdV) equation and a broad class of non-integrable generalized KdV (gKdV) equations in appropriate Sobolev spaces. This family of equations includes, as special cases, the standard gKdV equation with power nonlinearities as well as weakly nonlinear perturbations of the KdV equation. The distance estimates are based on a crucial size estimate for local gKdV solutions. Consequently, these estimates predict that the dynamics of the gKdV and KdV equations remain close over long time intervals for initial amplitudes approaching unity, while providing an explicit rate of deviation for larger amplitudes. Furthermore, it is demonstrated that in the case of power nonlinearities and large solitonic initial data, the deviation between the integrable and non-integrable dynamics can be drastically reduced by incorporating suitable rotation effects via a rescaled KdV equation. As a result, the integrable dynamics stemming from the rescaled KdV equation may persist within the gKdV family of equations over remarkably long timescales. Finally, we comment on similar results regarding Nonlinear Schrödinger (NLS) equations.

Nonlinear Waves Beyond the Laplacian Klein-Gordon and Nonlinear Schrodinger Settings

Schedule: July 9 13:30-14:00 Room 825

Panayotis Kevrekidis

University of Massachusetts, Amherst, USA

Abstract:

In the present work, we will explore a number of variants of the standard Klein-Gordon and NLS problems and study both kinks/dark solitons but also occasionally pulses/bright solitons in them. We will be motivated by the recent remarkable experimental realization of not only biharmonic, but also arbitrary fractional index Laplacian operators in nonlinear optics and we will see how the tails of the structures behave for different regimes of the fractional exponent α . This, in turn, will guide us to explore not only the soliton-soliton interactions, but also their stability. We will seek to present a unifying picture of the relevant interactions as a function of α , starting from the biharmonic setting and interpolating between that and the Laplacian one, as well as moving to the sub-Laplacian index case. Finally, we will touch upon dissipative variant of the problem, presently of interest, including the quartic Lugiato-Lefever equation and related problems that experiments are currently getting to.

New methods and results for Benjamin-Ono and related equations

Schedule: July 9 14:00-14:30 Room 825

Peter D Miller

University of Michigan, USA

Co-Author(s): Peter D. Miller

Abstract:

We describe some recent results on asymptotic properties of solutions of the Benjamin-Ono equation that have been obtained due to a breakthrough yielding an explicit formula for the solution of the Cauchy problem for this equation. Only a few integrable equations have been proved to have such a formula, which can be regarded as a rare and practically useful compact representation of all the parts of an inverse-scattering transform solution.

Existence and instability of periodic waves for KdV-Burgers equations with a source

Schedule: July 9 15:00-15:30 Room 825

Ramon G. Plaza

Universidad Nacional Autonoma de Mexico, Mexico

Co-Author(s): Raffaele Folino, Anna Naumkina

Abstract:

In this talk I will discuss the existence and (in)stability of periodic waves for equations of KdV-Burgers type with a source. In particular, I will discuss the existence of small-amplitude periodic waves for the KdV-Burgers-Fisher equation (with a source of Fisher-KPP type), which arise from a local bifurcation on the wave speed. Moreover, these periodic waves are spectrally unstable as solutions to the PDE, that is, the Floquet (continuous) spectrum of the linearization around each periodic wave intersects the unstable half plane of complex values with positive real part. I will also discuss how to conclude the orbital (nonlinear) instability of the waves departing from the spectral instability result for a general family of equations. This is joint work with Anna Naumkina and Raffaele Folino (IIMAS, UNAM).

Solitons in the 4th order NLS

Schedule: July 9 14:30-15:00 Room 825

Svetlana Roudenko

Florida International University, USA

Abstract:

The 4th order (or bi-harmonic) NLS equation has recently been attracting attention of scientists as the experimental quartic solitons, aka light bullets, have been obtained. We discuss solutions to this equation, examining more carefully the ground states in one- and two-dimensional settings. We look at the soliton dynamics, including stability, branching and long-time behavior. This talk is based on joint works with Iryna Petrenko (FIU, Miami) and Christian Klein & Nikola Stojilov (IMB, Dijon).

Special Session 119 : PDEs and Variational Problems in Physical and Biological Sciences

Organizer(s): Changfeng Gui , Wen Yang , Yeyao Hu

Introduction: Phenomena such as phase transitions and phase separation are ubiquitous across physics and biology, driving critical processes like superconductivity, population dynamics, and material self-assembly. Fundamental PDE and variational models—including the Allen-Cahn equation, Schrödinger-type systems, and geometric variational problems—serve as indispensable frameworks for capturing universal behaviors in these fields. Their mathematical structure offers profound insights into quantum mechanics, pattern formation, and interface dynamics. This special session showcases recent advances in analytical techniques and computational methods, emphasizing their dual role: resolving theoretical challenges while enabling predictive modeling for complex systems.

Stable spikes for some reaction diffusion systems modeling color pattern formation and consumer chain

Schedule: July 6 14:30-15:00 Room 825

Weiwei Ao

Wuhan University, Peoples Rep of China

Abstract:

In this talk, we will consider some reaction diffusion system with three components: one is a system for color pattern formation with two activators and one inhibitor, the other is consumer chain model which contains one consumer feeding on the producer and a second consumer feeding on the first consumer. We prove rigorous results on the existence and stability of some spikes solutions for these two models.

Diameter estimate of solutions to the even L_p Aleksandrov problem for -1

Schedule: July 6 18:00-18:30 Room 825

Yibin Feng

Lanzhou University, Peoples Rep of China

Co-Author(s): Shengnan Hu; Yuanyuan Li; Honglin Lv

Abstract:

Our recent work on diameter estimate of solutions to the even L_p Aleksandrov problem for -1

Critical Elliptic Boundary Value Problems with Singular Trudinger-Moser Nonlinearities

Schedule: July 7 9:00-9:30 Room 825

Shiqiu Fu

Jiangsu University, Peoples Rep of China

Co-Author(s): Kanishka Perera

Abstract:

In this talk, we give the existence results of solutions for two classes of elliptic problems that are critical with respect to singular Trudinger-Moser embedding. The proofs are based on compactness and regularity arguments.

Existence of normalized solutions for nonlinear Choquard equations

Schedule: July 6 18:30-19:00 Room 825

Qiuping Geng

Jiangsu University, Peoples Rep of China

Co-Author(s): Jun Wang

Abstract:

We study, using variational methods, the existence of normalized solutions to nonlinear Choquard equations under some parameter conditions.

Uniqueness and multiplicity for bistable equations in unbounded domains

Schedule: July 6 15:00-15:30 Room 825

Cle Graham

University of Wisconsin-Madison, USA

Co-Author(s): Henri Berestycki, Juncheng Wei.

Abstract:

In this talk, we explore the influence of geometry on bistable elliptic equations with Dirichlet boundary in unbounded domains. We present a surprising dichotomy between epigraphs that are bounded from below and domains containing a cone of aperture greater than π . The former admit exactly one positive bounded solution, while the latter support infinitely many. In the first case, we strengthen the method of moving planes to treat noncompact sublevel sets. In the second, we exploit a connection with Delaunay surfaces in differential geometry.

On the bifurcation diagram for free boundary problems arising in plasma physics

Schedule: July 6 17:00-17:30 Room 825

Aleks Jevnikar

University of Udine, Italy

Co-Author(s): D. Bartolucci, J. Wei, R. Wu

Abstract:

We are concerned with qualitative properties of the bifurcation diagram of a free boundary problem arising in plasma physics, showing in particular uniqueness and monotonicity of its solutions. We then discuss a new approach to study the Rabinowitz continuum of classical Gelfand problems.

Maximizing Reaction via Spatial Localization

Schedule: July 6 14:00-14:30 Room 825

Bo Li

University of California San Diego, USA

Co-Author(s): Yasir Khan

Abstract:

We study a PDE-constrained variational problem modeling spatial distributions of enzymes that maximize their reaction with substrates in biological cells. With a given enzyme concentration, the substrate concentration is determined by a reaction-diffusion equation. The reaction functional of enzyme concentrations is defined to be the total amount of reaction flux that is a nonlinear form of product of enzyme and substrate concentrations. We construct reaction-maximizing sequences through localization of enzymes, calculate the first and second variations of the reaction functional, and show the nonexistence of local and global maximizers. We further propose regularized reaction functionals and study their variational properties. Applications to biological cells are discussed. This is joint work with Yasir Khan.

Game-Theoretic Modeling of Adaptive Behavioral Responses in Epidemics

Schedule: July 7 8:30-9:00 Room 825

Tangjuan Li

Jiangsu University, Peoples Rep of China

Co-Author(s): Yanni Xiao, Jane M Heffernan

Abstract:

\begin{abstract} During disease outbreaks, individuals adopt preventive measures based on perceived infection risk and the associated costs. These behavioral responses, in turn, influence disease transmission dynamics. In this talk, we propose a co-evolutionary model that integrates adaptive behavioral changes into a classical epidemic framework to investigate their interplay. We show that such adaptive behavior can give rise to complex dynamical phenomena, including Hopf bifurcations, sustained periodic oscillations, and even some counterintuitive outcomes. Furthermore, by incorporating real-world behavioral data, we validate the proposed model and demonstrate its ability to capture key features of observed epidemic patterns.

\end{abstract}

Regularity from p -harmonic potentials to ∞ -harmonic potentials in convex rings

Schedule: July 7 8:00-8:30 Room 825

Fa Peng

School of Mathematical Sciences, Beihang University, Peoples Rep of China

Abstract:

The investigation of problems in shape metamorphism, surface reconstruction, and image interpolation raises fundamental questions concerning the higher-order regularity of ∞ -potentials (a class of ∞ -harmonic functions) and their approximation by p -harmonic potentials. In this talk, we establish interior C^1 and Sobolev regularity for ∞ -harmonic potentials in arbitrary convex ring domains, contributing to the core theory of ∞ -Laplace equations and L^∞ -variational problems. This is joint work with Prof. Yi Ru-Ya Zhang and Yuan Zhou.

A Priori Estimates for Fully Nonlinear Equations

Schedule: July 6 17:30-18:00 Room 825

Guohuan Qiu

Academy of Mathematics and Systems Science, Peoples Rep of China

Abstract:

This presentation introduces some progress in the interior regularity theory of fully nonlinear equations. For the equation of positive scalar curvature (also known as the 2-Hessian equation), we completely resolve the interior second-order derivative estimates in the three-dimensional case and for convex solutions. In higher dimensions, for the special Lagrangian curvature equation, we establish a priori interior curvature estimates in both the critical phase case and the convex case.

Analysis of a parabolic type system with singular initial data: existence, multiplicity and stability

Schedule: July 6 16:30-17:00 Room 825

Jun Wang

Jiangsu University, Peoples Rep of China

Co-Author(s): Qiuping Geng and Xuan Wang

Abstract:

In this talk, we present results on the existence and multiplicity of positive solutions and examine the stability of a parabolic Lane-Emden type system, with particular emphasis on cases involving singular initial data. On the other hand, we also investigate the asymptotic behavior, blow-up phenomena, and decay rates for the Henon-Hardy Lane-Emden type system.

Sign-changing solutions to discrete nonlinear logarithmic Kirchhoff equations

Schedule: July 7 9:30-10:00 Room 825

Lidan Wang

Jiangsu University, Peoples Rep of China

Abstract:

We study the discrete logarithmic Kirchhoff equation on $\mathbb{Z}^3$:

$$-\left(a + b \sum_{x \in \mathbb{Z}^3} |\nabla u(x)|^2\right) \Delta u(x) + (\lambda + 1)u(x) = |u|^{p-2} u \log |u|^2,$$

where $a, b > 0, p > 6$, and $\lambda > 0$. By using the Nehari manifold method, we prove the existence of least energy sign-changing solutions under suitable λ assumptions. We also analyze their asymptotic behavior as $\lambda \rightarrow \infty$ by introducing a limiting equation on bounded domains. Our results extend to n -dimensional lattice graphs $\mathbb{Z}^n$, with clear physical motivation from wave propagation and elastic vibration problems.

Global convergence of Gursky-Malchiodi flow

Schedule: July 6 13:30-14:00 Room 825

Juncheng Wei

Chinese University of Hong Kong, Hong Kong

Co-Author(s): Liuwei Gong, Sanghoon Lee

Abstract:

In their seminal work [JEMS 2015], Gursky and Malchiodi introduced a non-local conformal flow in dimensions $n \geq 5$ to resolve the constant Q -curvature problem. They proved sequential convergence of the flow for initial metrics with positive scalar curvature and Q -curvature, provided the initial energy is sufficiently small. The question of global convergence for large initial energy has remained open. In this talk, we resolve this problem by proving global convergence of the flow for arbitrary initial energy under the same positivity assumptions. Our approach centers on establishing a non-local version of the Łojasiewicz-Simon inequality for the Paneitz-Sobolev quotient along the flow. We construct test bubbles and estimate their Paneitz-Sobolev quotients, a strategy that was carried out in the celebrated work of Brendle (Invent 2006) in the context of the Yamabe flow. We develop a more geometric and systematic proof that addresses the algebraic and computational complexity inherent in the Q -curvature and the Paneitz operator. Along the way, we derive a stability inequality for the Paneitz-Sobolev quotient using a higher-order Koiso-Bochner formula established in recent work of Bahaud, Guenther, Isenberg, and Mazzeo (2025).

Spatial Pattern Formation and Spike Dynamics in a Three-Component Ecosystem Model

Schedule: July 6 15:30-16:00 Room 825

Shuangquan Xie

Hunan University, Peoples Rep of China

Abstract:

We introduce a three-component extension of the classical Klausmeire-Gray-Scott model, termed the WPAE model, to explore how water, vegetation, and allelopathic inhibition interact to generate complex spatial patterns in ecosystems. Departing from the classical two-component Klausmeier model, where limited resources tend to induce vegetation aggregation, our modified model demonstrates that allelopathic inhibition serves as a critical constraint, localizing vegetation populations specifically in water-abundant regimes. Moreover, we find that elevating the reaction rate of the allelopathic inhibitor leads to the emergence of robust traveling multi-spike solutions. Through systematic analysis, we observe a spectrum of complex spike interactions, including merging, repulsive bouncing, and more sophisticated dynamics involving splitting and competition. This work aims to unravel the underlying mechanisms driving these phenomena. Our approach involves first constructing a single stationary spike solution using matched asymptotic expansions and examining its spectral stability. We further derive explicit traveling spike solutions and obtain governing equations for their propagation speed. The validity of our theoretical results is confirmed via numerical simulations, which show strong consistency with our analytical findings.

Special Session 120 : Mixtures: Modeling, analysis and computing

Organizer(s): Miroslav Bul'ík, Vít Průša, Karel Tuřina

Introduction: This session focuses on mathematical, numerical, and modelling challenges that arise in mixture theory, particularly in connection with systems of partial differential equations that describe such phenomena. The talks will cover all relevant aspects, from the development of physically and mathematically adequate models, through the analysis of the associated equations, to their numerical simulation. Various approaches to handling mixture systems will be presented, including those that incorporate stochastic processes. The emphasis is placed on the interaction between modelling, analysis, and computation to advance the understanding of the behaviour of complex mixtures.

Finite element methods for electroneutral multicomponent convection-diffusion

Schedule: July 7 13:30-14:00 Room 824

Aaron Baier-Reinio

University of Oxford, England

Abstract:

We present novel high-order finite element methods for the coupled Navier--Stokes and Onsager--Stefan--Maxwell equations, which model bulk momentum transport, multicomponent cross-diffusion and electrical effects within mixtures. We discuss some salient properties of our numerical schemes and discuss challenges that arise when discretising the governing equations. Our approach naturally extends to handle local electroneutrality when the species carry electrical charge, making our methods particularly desirable for simulating liquid electrolytes in electrochemical applications. We present numerical simulations involving (i) the microfluidic non-ideal mixing of hydrocarbons and (ii) the flow in a Hull cell of a cosolvent electrolyte mixture used in lithium-ion batteries.

Structure-preserving approximation for the quasi-incompressible Maxwell-Stefan-Navier-Stokes system

Schedule: July 7 14:00-14:30 Room 824

Aaron Brunk

Johannes-Gutenberg University Mainz, Germany

Co-Author(s): Ansgar Juengel, Maria Lukacova-Medvidova

Abstract:

In this talk, we present a conforming finite element method for the quasi-incompressible Navier--Stokes--Maxwell--Stefan system. The model couples the Navier--Stokes equations with a quasi-incompressibility constraint and a cross-diffusion Maxwell--Stefan system describing multicomponent mass transport. Our scheme combines a mixed explicit--implicit time discretization with a spatially conforming finite element approximation, ensuring the preservation of partial masses, strict enforcement of the quasi-incompressibility condition, and dissipation of a discrete analogue of the total energy. Furthermore, we present an a priori error analysis of the fully discrete scheme based on the relative entropy method. The proof leverages the structure-preserving properties of the discretization, including discrete energy dissipation and the control of the cross-diffusion terms. Numerical experiments in two space dimensions complement the analysis. They illustrate the predicted convergence rates, confirm the robustness of the error estimate, and demonstrate the correct qualitative behaviour of multicomponent flows, including mass conservation and energy decay. The results show that the proposed scheme provides a reliable and physically consistent computational framework for the simulation of quasi-incompressible multicomponent fluid mixtures. If time permits we will discuss extensions to the non-isothermal case. This is joint work with Ansgar Juengel and Maria Lukacova-Medvidova

Stability of the rest state for some models of viscous chemically reacting fluids

Schedule: July 6 13:30-14:00 Room 824

Miroslav Bulířek

Charles University, Czech Rep

Abstract:

We analyse a model for heat-conducting, chemically reacting fluid mixtures with cross-effects and discuss the stability of the rest state. Our main goal is to provide a rigorous stability result at the level of weak solutions. The main idea is to follow the relative energy and entropy framework to construct a suitable Lyapunov-like functional, specifically designed for the considered fluid system.

Multicomponent flow in domains with moving boundary: discretizations and numerical simulations

Schedule: July 7 14:30-15:00 Room 824

Lenka Kováčková

Charles University, Czech Rep

Co-Author(s): Jaroslav Hron, Patrick Farrell

Abstract:

We consider a multicomponent flow in which diffusion is described either by Fick's law or by the Stefan-Maxwell equations, where the latter one also allows to capture cross-diffusive effects. We account for the motion of the domain and reformulate the equations in the Arbitrary Lagrangian-Eulerian framework. We then discuss various discretizations of the governing equations under different boundary conditions and present numerical simulations of the system in some simplified settings.

Chemically reacting mixtures: asymptotic stability of steady solutions

Schedule: July 6 14:30-15:00 Room 824

Tobias Krupa

Charles University, Czech Rep

Co-Author(s): Miroslav Bulíček

Abstract:

In many applications, we are interested in mixtures in which chemical reactions occur. There is a well-known theory of mixtures that can capture this effect in its equations. However, the terms describing the interchange of mass between the constituents are often quite complicated and nonlinear. One important particularly studied aspect is the equilibrium state, especially in cases involving multiple independent chemical reactions. In such cases, we study the existence, uniqueness, and, most importantly, the stability of the steady solution to the coupled system of equations for the velocity field and the concentrations of the constituents equipped with various boundary conditions. The analysis is performed within the framework of mixture models, where the mixture moves collectively together at a single barycentric velocity, while the partial fluxes of the constituents are modeled at the constitutive level.

Existence analysis of an evolutionary compressible fluid model for heat-conducting and chemically reacting mixtures

Schedule: July 6 15:00-15:30 Room 824

Milan Pokorný

Charles University, Czech Rep

Co-Author(s): Miroslav Bulíček, Ansgar Juengel, Nicola Zamponi

Abstract:

The existence of large-data weak solutions to the evolutionary compressible Navier--Stokes--Fourier system for chemically reacting fluid mixtures is proved. General free energies are considered satisfying some structural assumptions, with a pressure containing a γ -power law. The model is thermodynamically consistent and contains the Maxwell--Stefan cross-diffusion equations in the Fick--Onsager form as a special case. Compared to previous works, a very general model class is analyzed, including cross-diffusion effects, temperature gradients, compressible fluids, and different molar masses. A priori estimates are derived from the entropy balance and the total energy balance. The compactness for the total mass density follows from an estimate for the pressure in L^p with $p > 1$, the effective viscous flux identity, and uniform bounds related to Feireisl's oscillations defect measure. These bounds rely heavily on the convexity of the free energy and the strong convergence of the relative chemical potentials.

Modeling metamaterials by second-order rate-type constitutive relations between only the macroscopic stress and strain

Schedule: July 7 15:30-16:00 Room 824

Vit Prusa

Charles University, Czech Rep

Abstract:

We discuss a novel thermodynamically based approach for constructing effective rate-type constitutive relations describing finite deformations of metamaterials. The effective constitutive relations are formulated as second-order in time rate-type Eulerian constitutive relations between only the Cauchy stress tensor, the Hencky strain tensor, and objective time derivatives thereof. In particular, there is no need to introduce additional quantities or concepts such as micro-level deformation, micromorphic continua, enriched continua, or elastic solids with frequency dependent material properties. The linearisation of the proposed fully nonlinear (finite deformations) constitutive relations leads, in Fourier space, to the same dispersion relations as those commonly used in metamaterial theories based on the concepts of frequency dependent density and/or stiffness. From this perspective the proposed constitutive relations reproduce the behaviour predicted by the frequency dependent density and/or stiffness models, but yet they work with constant --- that is motion independent --- material properties. The behaviour predicted by the linearised models is documented through numerical experiments exploiting a recently proposed dispersion-relation preserving discretisation. Finally, we argue that the proposed fully nonlinear (finite deformations) second-order in time rate-type constitutive relations do not fall into the traditional classes of models for elastic solids (hyperelastic solids/Green elastic solids, first-order in time hypoelastic solids), and that the proposed constitutive relations embody a new class of constitutive relations characterising elastic solids.

Homogenization Limits for Compressible Liquid-Vapour Flow with Phase Transition

Schedule: July 6 17:00-17:30 Room 824

Christian Rohde

University of Stuttgart, Germany

Co-Author(s): Jens Keim, Florian Wendt

Abstract:

In the lecture we consider mathematical models for the evolution of two-phase fluids in free flow and porous media settings addressing diffuse-interface approaches. A special focus will be on Navier-Stokes-Korteweg (NSK) systems that describe on a detailed scale compressible liquid-vapour fluids which account for phase transition. We present rigorous results for homogenization in periodic porous media that lead to a Cahn-Hilliard-type evolution equation on the Darcy scale. Furthermore we discuss the upscaling of NSK motion for highly oscillating initial data on the corresponding Baer-Nunziato scale. The latter limit results in a mixed type continuum-mechanical/kinetic evolution system.

Convergent numerical methods for viscoelastic fluid models

Schedule: July 6 17:30-18:00 Room 824

Dennis Trautwein

University of Regensburg, Germany

Co-Author(s): Endre Suli

Abstract:

In this talk, we review a class of energy-stable numerical methods for the viscoelastic Oldroyd-B and Giesekus models. The model couples the incompressible Navier--Stokes equations with an evolution equation for an additional stress tensor accounting for elastic effects. This coupled evolution equation models transport and nonlinear relaxation effects and is usually stated in terms of the elastic deformation gradient, the conformation tensor, or the log-conformation approach. In the existing literature, numerical schemes for such models often suffer from accuracy limitations and convergence problems, usually due to the lack of rigorous existence results or inherent limitations of the discretization. The core of this presentation introduces a novel convergence result. We prove the (subsequence) convergence of a proposed numerical method to a large-data global weak solution of the Giesekus model in two dimensions. Crucially, this result is achieved without the use of artificial cut-offs or regularization in the limit system, providing a constructive alternative to the existence proof by Bul'nikov et al. (Nonlinearity, 2022). Finally, we demonstrate the robustness of the method through numerical experiments, including convergence rate studies and typical benchmark problems.

A multiwell phase-field model for arbitrarily strong total-spreading case

Schedule: July 6 18:30-19:00 Room 824

Karel Tuma

Faculty Of Mathematics And Physics, Charles University, Czech Rep

Co-Author(s): J. Kozlík, O. Souček, J. Dobrzański, S. Stupkiewicz

Abstract:

Motivated by the β -- ω transformation in titanium alloys, we study the total-spreading regime in which two ω variants can not form a direct interface and must remain separated by the parent β phase. Building on the classical multiwell framework and the consistency requirements discussed by Boyer and Lapuerta (2006), we show that the standard model works only in a limited parameter range and may fail under strong chemical driving force. To overcome this limitation, we propose a modified multiwell phase-field model with an additional interfacial-energy term that penalizes mixed ω -- ω states and enforces separation of ω variants by the β phase. At the same time, the model preserves the desired behavior of purely two-phase β -- ω states. Numerical examples in one spatial dimension show proper separation of four ω variants by the β phase and monotone decay of the total free energy. Two- and three-dimensional simulations further show the formation of thin β layers at contacts between variants and the subsequent coarsening of the microstructure. The model provides a natural starting point for future extensions with a more realistic chemical background.

Bulk-Surface Coupling in Brain Tissue: A Multiscale Mixture Model for Amyloid-beta

Schedule: July 6 18:00-18:30 Room 824

Lucie Wintrova

Mathematical Institute of Charles University, Czech Rep

Co-Author(s): Marie Rognes, Miroslav Bulíček

Abstract:

Transport and clearance of amyloid- β in the brain tissue involve coupled diffusion-reaction processes in the interstitial bulk and receptor-mediated interactions on cellular interfaces, leading naturally to a bulk-surface system. These mechanisms operate across strongly separated spatial scales: microscopic cellular geometries determine local transport behavior, whereas clinically relevant observations concern macroscopic tissue domains. We formulate a microscale class I mixture model posed on a periodically perforated domain, incorporating bulk diffusion, nonlinear surface reactions, and interfacial exchange. Using two-scale convergence techniques, we rigorously derive an effective macroscopic model that retains explicit dependence on the underlying microstructure through effective transport and reaction coefficients. The analysis establishes a systematic link between microscopic structure and macroscopic transport laws, yielding a model suitable for large-scale simulation.

Multi-phase cross-diffusion models for tissue structures

Schedule: July 7 15:00-15:30 Room 824

Sara Xhahysa

TU Wien, Austria

Co-Author(s): Ansgar Jüngel, Cordula Reisch

Abstract:

Volume-filling cross-diffusion equations for the components of a tissue structure are formally derived from mass conservation laws and force balances for the interphase pressures and viscous drag forces in a multiphase approach. The equations include Maxwell--Stefan, tumor-growth, thin-film solar cell models as well as novel volume-filling population systems. The Boltzmann and Rao entropy structures are explored. If the drag coefficients are all equal to one, the global-in-time existence of bounded weak solutions, their long-time behavior, and the weak--strong uniqueness of solutions to a regularized system are proved using entropy methods. In the general case, the resulting diffusion matrix is positively stable, ensuring local-in-time existence of solutions. Global-in-time existence of weak solutions is proved if the drag coefficients are sufficiently close to each other. This restriction is explained by the fact that the pressure forces are of degenerate type, while the drag forces are nondegenerate in the volume fractions. Numerical simulations are presented in one space dimension to illustrate the solution behavior beyond the entropy regime.

Richards flow in porous media with cross diffusion

Schedule: July 6 15:30-16:00 Room 824

Nicola Zamponi

University of Augsburg, Germany

Co-Author(s): Esther S. Daus, Josipa-Pina Milić

Abstract:

We study a non-isothermal simplified two-phase air-water flow in porous media, where the water phase is modelled as a mixture of N chemical components. The governing system consists of mass conservation equations for each component, an energy balance equation, and a capillary pressure relation. The model is thermodynamically consistent and incorporates cross-diffusion effects arising from multicomponent interactions. Our main result establishes the sequential stability of weak variational entropy solutions. The analysis relies on a priori estimates derived from the entropy balance and the total energy balance, together with a dynamic capillary pressure law. Compactness arguments are carried out using the Div-Curl lemma, which allows us to pass to the limit in the nonlinear terms.

Existence, uniqueness and asymptotic stability of invariant measures for the stochastic Allen-Cahn-Navier-Stokes system with singular potential.

Schedule: July 6 16:30-17:00 Room 824

Margherita Zanella

Politecnico di Milano, Italy

Co-Author(s): Andrea di Primio, Luca Scarpa

Abstract:

In this talk we present the study of the long-time behaviour of a stochastic Allen-Cahn-Navier-Stokes system. The model features two stochastic forcings, one on the velocity in the Navier-Stokes equation and one on the phase variable in the Allen-Cahn equation, and includes the thermodynamically relevant Flory-Huggins logarithmic potential. We first show existence of ergodic invariant measures. Secondly, we prove that if the noise acting in the Navier-Stokes equation is nondegenerate along a sufficiently large number of low modes, and the Allen-Cahn equation is highly dissipative, then the stochastic flow admits a unique invariant measure which is asymptotically stable with respect to a suitable Wasserstein metric. The talk is based on a joint work with A. Di Primio and L. Scarpa.

On the low Mach number limit for compressible two-fluid system

Schedule: July 6 14:00-14:30 Room 824

Ewelina Zatorska

University of Warwick, England

Co-Author(s): Yang Li, Nilasis Chaudhuri

Abstract:

In this talk I will focus on two results justifying the low Mach Number limit for the compressible two-fluid system in the regime of strong and weak solutions. In the framework of local-in-time strong solutions, we prove that, for well-prepared initial data, solutions to the rescaled compressible two-fluid system exist on a time interval independent of the Mach number and converge to the solution of the incompressible Navier-Stokes equations as the Mach number tends to zero. In the framework of weak solutions, our recently developed method of relative entropies, can be applied to identify the inhomogeneous incompressible Navier-Stokes equations as the limiting system when the Mach number goes to zero, even in the ill-prepared data case. The proof is based on the relative entropy method and the dispersive estimates of the acoustic waves.

Abstracts for Special Sessions

Special Session 122 : Topological Data Analysis Theory, Algorithms, and Applications

Organizer(s): Firas Khasawneh

Introduction: This special session focuses on recent advances in the theory and applications of Topological Data Analysis (TDA). This includes research on the topology of random, high-dimensional, or time-varying data, cycle representatives, shape analysis with TDA, as well as theory, algorithms and software for topological computations. Applications that showcase the utility of TDA in various fields or highlight opportunities for future advances in theory or algorithms are also welcome.

Hausdorff vs Gromov-Hausdorff distances

Schedule: July 9 9:30-10:00 Room 538

Henry Adams

University of Florida, USA

Abstract:

Tools from topology can bound or compute quantities arising in metric geometry. An example geometric quantity is the Hausdorff or Gromov-Hausdorff distance between two metric spaces (or datasets). Though Hausdorff distances are easy to compute, Gromov-Hausdorff distances are not. An example topological tool is the nerve lemma: a good cover of a space faithfully encodes the shape of that space. When X is a sufficiently dense subset of a closed Riemannian manifold M , we can use the nerve lemma to lower bound the Gromov-Hausdorff distance between X and M by $1/2$ the Hausdorff distance between them. The constant $1/2$ can be improved, and even obtains the optimal value 1 (meaning the Hausdorff and Gromov-Hausdorff distances coincide) when M is the circle.

Higher-order connectomics of human brain function

Schedule: July 8 13:30-14:00 Room 538

Enrico Amico

University of Birmingham, England

Co-Author(s): Enrico Amico

Abstract:

Traditional models of human brain activity often represent it as a network of pairwise interactions between brain regions. Going beyond this limitation, recent approaches have been proposed to infer higher-order interactions from temporal brain signals involving three or more regions. However, to this day it remains unclear whether methods based on inferred higher-order interactions outperform traditional pairwise ones for the analysis of fMRI data. In this talk I will introduce a novel approach to the study of interacting dynamics in brain connectomics, based on higher-order interaction models. Our method builds on recent advances in simplicial complexes and topological data analysis, with the overarching goal of exploring macro-scale and time-dependent higher-order processes in human brain networks. I will present our preliminary findings along these lines, and discuss limitations and potential future directions for the exciting field of higher-order brain connectomics.

Studying 2-Parameter Persistent Homology via Directed Topology

Schedule: July 9 17:00-17:30 Room 538

Robin Belton

Vassar College, USA

Abstract:

Studying 2-Parameter Persistent Homology via Directed Topology, Although multi-parameter persistence modules contain more information than single-parameter persistent homology, they are more difficult to understand, visualize, and integrate into a data analysis pipeline. We propose a new construction for relating the parameter space of a 2-parameter persistence module to a directed space. We discuss how this construction relates the set of 1-d persistence diagrams along non-decreasing paths for a particular 2-parameter persistence module, to the space of directed paths in the parameter space of that module. From this construction, we can use directed collapses to simplify the parameter space while still maintaining information to understand the module.

ZZFormer: A Sliding Window Zigzag Persistent Homology Transformer for Repetitive Biological Sequences

Schedule: July 9 15:30-16:00 Room 538

Dhananjay Bhaskar

University of Wisconsin-Madison, USA

Co-Author(s): Kritika Kumari, Levi Meng Hong Svaren

Abstract:

Repeated patterns occur in biological sequences, neural activity, and in tokenized representations of data across many domains. Modeling such repetition is central to sequence analysis, but remains challenging for modern learning methods. While transformer architectures can capture long-range dependencies, they do not explicitly account for recurrence or cyclic structure, which are key features in many sequences. We introduce a topological framework for learning on sequences with repetition using zigzag persistent homology. As a sliding window moves along a sequence, this construction detects and tracks repeated patterns through the appearance and persistence of loops. Building on this idea, we develop ZZFormer, a transformer architecture that incorporates zigzag topological structure directly into token embeddings, enabling end-to-end learning on variable-length sequences. By encoding repetition explicitly, ZZFormer provides a way to incorporate topological structure into sequence models. This framework applies broadly to problems involving repeated or cyclic patterns. We demonstrate its effectiveness on tasks involving repetitive DNA, including classification of transposable element superfamilies and orders.

TopoFormer: Topology Meets Attention for Graph Learning

Schedule: July 9 14:00-14:30 Room 538

Baris Coskunuzer

University of Texas at Dallas, USA

Co-Author(s): Md Joshem Uddin, Astrit Tola, Cuneyt Gurcan Akcora

Abstract:

In this talk, we show that reshaping topological ideas to fit modern deep learning pipelines can substantially improve graph learning. We present TopoFormer, a lightweight framework that injects topological inductive bias into transformer based models by converting each graph into a short sequence of topology aware tokens. The core module, Topo-Scan, slices a graph using node or edge filtrations to produce an ordered token sequence that captures multi scale structure, from local motifs to global organization, in a form naturally suited to attention. Unlike classical persistent homology pipelines, Topo-Scan is parallelizable, avoids costly persistence diagram computations, and integrates cleanly into end to end training. We provide stability guarantees for the proposed encodings and demonstrate state of the art performance on graph classification and molecular property prediction benchmarks, matching or surpassing strong GNN and topology based baselines while remaining scalable and compute predictable.

Dynamics meets topological data analysis

Schedule: July 8 16:30-17:00 Room 538

Pawel Dlotko

Warsaw University, Poland

Abstract:

Topological data analysis (TDA) is usually associated with point clouds and scalar filtrations, but many problems in dynamics naturally come with richer objects: finite trajectory segments, delay-coordinate reconstructions, or vector fields known either analytically or only through sampling. In this talk I will discuss a collection of recent TDA-inspired methods that shift the focus from the topology of static data to the comparison of dynamical systems themselves \cite{Carlsson2009,EdelsbrunnerHarer2010}. On the one hand, I will present tests for topological conjugacy constructed from finite orbit samples and time series, including a formulation based on Takens reconstructions, which makes it possible to assess whether two observed processes encode the same underlying dynamics \cite{Takens1981,DlotkoLipinskiSignerska2024}. On the other hand, I will describe new descriptors for sampled and continuous vector fields---including begin--end point embeddings, densities of directions, Euler characteristic curves, and Euler characteristic profiles---designed to compare dynamics directly at the level of trajectories or vector fields, detect qualitative changes such as bifurcations, and remain computationally feasible in data-driven settings \cite{MarszewskaSignerskaRynkowskaDlotkoInPrep}. Taken together, these methods show that ideas originating in TDA can be turned into practical tools for the quantitative and qualitative analysis of dynamics well beyond the standard point-cloud setting: from finite samples of trajectories to sampled or continuous vector fields, and from discrete observations to analytically defined systems.

Probabilistic Statements for Mapper Graphs

Schedule: July 9 16:30-17:00 Room 538

Halley Fritze

University of Michigan, USA

Co-Author(s): Enrique Alvarado, Robin Belton, Nicholas Della Pesca, Aine Doherty

Abstract:

The Mapper algorithm is a popular exploratory data analysis tool for visualizing the underlying graphical structure of a dataset. The Mapper algorithm involves several user specified parameters that make it possible for any graph to be a Mapper graph. We investigate the question of how likely we are to see specific types of subgraphs within a Mapper graph, when data points are randomly sampled from a continuous probability density function. We provide both theoretical and experimental results for how likely we are to get cyclic subgraphs within a Mapper graph. Additionally, we discuss how we can generalize these probabilistic results and use them as a starting point for a statistical inference framework with Mapper graphs.

Generalised Wasserstein Metrics on Persistence Diagrams via Banach Sequence Ideals

Schedule: July 9 9:00-9:30 Room 538

Fernando Galaz-Garcia

Durham University, England

Co-Author(s): Mauricio Che, Fernando Galaz-Fontes

Abstract:

Persistence diagrams may be thought of as countable multisets of points in a metric space X , considered relative to a distinguished nonempty closed subset $A \subset X$. Their comparison is usually based on the bottleneck distance or on p -Wasserstein distances. In this talk, I will present a common framework in which these distances arise as instances of a more general construction involving a normalized permutation-invariant Banach sequence ideal E , with the norm of E used as the cost function in the corresponding optimal transport problem between persistence diagrams. This yields a family of spaces of persistence diagrams parametrized by the Banach sequence ideal E , extending earlier definitions of diagram metrics. I will explain natural assumptions on E under which the resulting matching formula defines a metric and the associated spaces of persistence diagrams are complete, separable, and geodesic. In this way, the framework enlarges the class of metrics available for applications while preserving the main structural properties of the classical diagram spaces. The bottleneck and p -Wasserstein distances are recovered as the special cases $E = \ell^\infty$ and $E = \ell^p$.

How do biological neural networks learn topologically structured data?

Schedule: July 8 14:00-14:30 Room 538

Chad Giusti

Oregon State University, USA

Co-Author(s): Nikolas Schonscheck

Abstract:

Populations of neurons in the brain encode complex information through the aggregate activity -- so called spikes -- of neurons in those populations. Dimensionality reduction methods are commonly used to qualitatively investigate such population activity, driving much modern understanding of the function of neural systems. However, when the represented information carries non-trivial topology, these methods can obscure salient structure. Topological methods have been successfully employed to characterize non-linear organizing principles of neural population activity. As these work without dimensionality reduction, we can use them to investigate fundamental questions about population behavior. For example, is propagation of nonlinear coordinate systems a generic feature of biological neural networks, or must this be learned? If learning is necessary, what mechanisms can produce it? In this talk, we will apply recent developments in TDA to demonstrate that simple Hebbian spike-timing dependent plasticity reorganizes feed-forward networks to correctly propagate toroidal coordinate systems. We also observe the emergence of geometrically non-local receptive field types, postdicting several experimentally observed phenomena. These observations provide quantitative support for the hypothesis that simple biologically plausible plasticity mechanisms suffice explain topological organization observed in real neural systems.

Shapes, Spaces, Simplices, and Structure: Geometry, Topology, and Machine Learning

Schedule: July 9 13:30-14:00 Room 538

Bastian Grossenbacher-Rieck

University of Fribourg, Switzerland

Abstract:

A large driver contributing to the undeniable success of deep learning models is their ability to synthesize task-specific features from data. For a long time, the predominant belief was that "given enough data, all features can be learned." However, as large language models are hitting diminishing returns in output quality while requiring an ever-increasing amount of training data and compute, new approaches are required. One promising avenue involves focusing more on aspects of modeling, which involves the development of novel inductive biases such as invariances that cannot be readily gleaned from the data. This approach is particularly useful for data sets that model real-world phenomena, as well as applications where data availability is scarce. Given their dual nature, geometry and topology provide a rich source of potential inductive biases. In this talk, I will present novel advances in harnessing multi-scale geometrical-topological characteristics of data. A special focus will be given to show how geometry and topology can improve representation learning tasks. Underscoring the generality of a hybrid geometrical-topological perspective, I will furthermore showcase applications from a diverse set of data domains, including point clouds, graphs, and higher-order combinatorial complexes.

The Shape of Orbits in the Circular Restricted Three-Body Problem: Opportunities for Topological Data Analysis

Schedule: July 7 18:00-18:30 Room 538

Davide Guzzetti

Auburn University, USA

Co-Author(s): Davide Guzzetti

Abstract:

Within an unperturbed central-body gravitational field, Keplerian orbital elements provide both a coordinate representation and an intuitive geometric description, enabling clear visualization of orbit properties and intuitive design of spaceflight solutions. In contrast, for the Circular Restricted Three-Body Problem (CR3BP), no compact and expressive parameterization exists that plays an analogous role to Keplerian elements or other two-body coordinate sets. This limitation creates a disconnect between commonly used state representations and salient orbit features that are readily observable yet not rigorously encoded.

Topological data analysis (TDA) offers a promising pathway to bridge this gap by augmenting coordinate descriptions with topological, potentially geometry-aware, signatures and distance metrics that capture the intrinsic shape of orbits. Such representations may enable a more faithful characterization of nonlinear dynamical behavior and provide a principled basis for comparing underlying structures and signals linked to orbit motion. Extending these ideas across models of varying fidelity, as well as to observational sensor data streams, opens new opportunities for enhanced space domain awareness and orbit motion inference in cislunar environments.

Quantum computing and persistence in topological data analysis

Schedule: July 7 17:30-18:00 Room 538

Ryu Hayakawa

Kyoto University, Japan

Co-Author(s): Ryu Hayakawa

Abstract:

It has been recently revealed that surprising connections exist between topological data analysis and quantum computing. In this talk, I will show a quantum algorithm for estimating persistent Betti numbers, which is a central quantity in TDA. Moreover, I will show a complexity theoretic evidence that quantum computing exponentially outperforms classical computing for certain problems in TDA.

New Method for Analyzing The Hole-Structure of a Crystal: Merge Tree for Periodic Data

Schedule: July 8 8:00-8:30 Room 538

Teresa Heiss-Synak

the Australian National University, Australia

Co-Author(s): Herbert Edelsbrunner

Abstract:

Periodic data is abundant in materials science; for example, the atoms of a crystalline material repeat periodically. Additionally, periodic boundary conditions are used in many simulations, for example in molecular dynamics simulations of materials, to remove boundary effects. However, it is unclear how to deal with the periodicity of the data when computing topological descriptors, like the merge tree or persistent homology, which track connected components or holes at different length scales. A classical approach is to compute the respective descriptor simply on the torus. However, this does not give the information needed for many applications and is even unstable under certain types of noise. Therefore, we suggest decorating the merge tree gained from the torus with additional information, describing for each connected component on the torus how many components of the infinite periodic space map to it. As there are often infinitely many, we describe their density and growth rate inside a growing sphere. The resulting periodic merge tree and its induced periodic 0-th persistence barcode carry the desired information and satisfy the desired properties, in particular: stability and efficient computability (under mild assumptions, the running time is of order $(n + m)\log(n)$, where n and m are the number of vertices and edges per fundamental domain).

Robustness of persistent homology when noising and denoising 3D images

Schedule: July 8 9:30-10:00 Room 538

Jonathan Jaquette

New Jersey Institute of Technology, USA

Co-Author(s): Ebru Dagdelen, Aakash Karlekar, Manav Arora, Matthew Illingsworth, Jonathan Jaquette, Linda J. Cummings, Lou Kondic

Abstract:

The classical bottleneck stability theorem tells us that two functions which are close in the sup norm will yield persistence diagrams which are close in the bottleneck distance; that C^0 perturbations may only produce small changes in the lifespans of generators. There is no guarantee, however, on the number of generators which may be produced by such a perturbation. Indeed, millions of such generators may arise when studying noisy datasets, presenting an obstacle to both (1) the actual computation of persistent homology (PH) of large 3D images, and (2) any analysis of PH which incorporates the number of generators. As such, it is often necessary to denoise the data before computing its PH. In this talk, we analyze the PH of synthetic 3D images of porous media in the presence of spatially uncorrelated noise, and perform a comparative analysis of various topological measures (e.g. bottleneck distance, Wasserstein distance, persistence statistics, persistence images, etc.) to assess their robustness to the noising and denoising process.

Detecting Stochasticity in Discrete Signals via Persistent Homology

Schedule: July 8 17:00-17:30 Room 538

Firas Khasawneh

Michigan State University, USA

Co-Author(s): Sunia Tanweer

Abstract:

Distinguishing deterministic chaos from stochastic dynamics in discrete time series remains a fundamental and challenging problem, particularly in the presence of noise and limited data. Prior work has explored subjective metrics like entropy as a framework for capturing structural invariants between such signals---motivating the search for a robust, theoretically grounded method. In this work, we develop a nonparametric, theory-driven method based on excursion statistics of stochastic processes. Building on classical results on the persistent homology for continuous semimartingales, we exploit a universal scaling law relating the number of barcodes of size ϵ to the quadratic variation of the signal. This yields a simple and interpretable diagnostic: stochastic diffusion processes exhibit an inverse-squared scaling in barcodes/excursion counts, while deterministic systems---periodic or chaotic---systematically violate this behavior. Using this principle, we construct a data-driven classification framework that operates directly on a single observed time series without embedding, symbolic transformations, or model training. We demonstrate the effectiveness of the method across a wide range of systems, including canonical stochastic diffusions, deterministic chaotic maps and flows, noisy hybrid systems, and real-world datasets including financial time series and audio signals.

Interleaving distance as a Galois-edit distance

Schedule: July 9 8:30-9:00 Room 538

Woojin Kim

KAIST, Korea

Abstract:

The concept of edit distance, which dates back to the 1960s in the context of comparing word strings, has since found numerous applications with various adaptations in computer science, computational biology, and applied topology. By contrast, the interleaving distance, introduced in the 2000s within the study of persistent homology, has become a foundational metric in topological data analysis. In this work, we show that the interleaving distance on finitely presented single- and multi-parameter persistence modules can be formulated as a so-called Galois-edit distance. The key lies in clarifying a connection between the Galois connection and the interleaving distance, via the established relation between the interleaving distance and free presentations of persistence modules. In addition to offering new perspectives on the interleaving distance, we expect that our findings will facilitate the study of stability properties of invariants of multi-parameter persistence modules. As an application of the edit formulation of the interleaving distance, we present an alternative proof of the well-known bottleneck stability theorem.

Digitalizing the Euler Characteristic Transform

Schedule: July 8 8:30-9:00 Room 538

Henry Kirveslahti

University of Southern Denmark, Denmark

Co-Author(s): Xiaohan Wang

Abstract:

The Euler Characteristic Transform of Turner et al. is a TDA-inspired tool that can be used for statistical shape analysis. This transform enjoys many desirable mathematical properties that make it very appealing for applications. However, the transform is typically discretized, and this process complicates the maximal exploitation of the beautiful theory behind it. In this talk, we present how this transform can be represented in a truly lossless way in the spirit of digitalization of the Kendall Shape Space. We demonstrate that this digital representation is practically feasible to compute and can be made auto-differentiable to benefit from synergies with deep learning. We will also outline some directions for theoretical research that would allow us to tackle more ambitious applied problems with this new representation. This is joint work with Xiaohan Wang.

The shadow of Vietoris-Rips complexes in limits

Schedule: July 9 18:00-18:30 Room 538

Atish J Mitra

Montana Technological University, USA

Co-Author(s): Sushovan Majhi, Kazuhiro Kawamura

Abstract:

The Vietoris-Rips (VR) complex of a metric space at a certain scale is an abstract simplicial complex where each k -simplex corresponds to $(k+1)$ -point sets with diameter less than that scale. The pioneering work by Hausmann established that any closed Riemannian manifold is homotopy equivalent to its Vietoris-Rips complex for sufficiently small scales. This fundamental result naturally motivated the finite reconstruction problem of a manifold with a finite Hausdorff close sample, which was answered by Latschev. For any abstract simplicial complex whose vertex set is a Euclidean subset, its shadow is the union of the convex hulls of its simplices. We consider the homotopy properties of the shadow of VR complexes, along with the canonical projection map from the VR complex to its shadow. The study of the geometric/topological behavior of this projection map is a natural yet non-trivial problem, and the map may have many ``singularities`` which have been partially resolved only in dimensions up to 3. We address the challenge posed by singularities in the shadow projection map by studying systems of the shadow complex using inverse system techniques from shape theory, showing that the limit map exhibits favorable homotopy-theoretic properties. More specifically, leveraging ideas and frameworks from shape theory, we show that in the limit when the scale approaches zero and the sample becomes increasingly dense, the limit map behaves well with respect to homotopy/homology groups when the space is an ANR (absolute neighborhood retract) and admits a metric that satisfies some regularity conditions. This results in Hausmann-type and Latschev-type reconstruction theorems in the limit.

Building Canopies for the Decomposition of Persistence Bundles

Schedule: July 9 17:30-18:00 Room 538

Elizabeth Munch

Michigan State University, USA

Co-Author(s): Elizabeth Munch, Barbara Giunti

Abstract:

Static persistence, that is the persistent homology computed for a single filtration function $f : K \rightarrow \mathbf{R}$, has been highly utilized throughout topological data analysis. The first work looking at the persistent homology for a parameterized family of functions, $f_p : K \rightarrow \mathbf{R}$, came in the form of vineyards by Morozov et al, where the parameterization was over some interval, i.e. $p \in [a, b]$. More recently, there has been a growing interest in parameterized persistence where $p \in B$ for some more complex base space. For example, Turner et al introduced the Persistent Homology Transform (PHT), which studies the persistence of a family of functions on an embedded space $|K| \subset \mathbf{R}^n$ parameterized over $p \in \mathbf{S}^{n-1}$. The most general form of this came with the introduction of persistent homology bundles by Hickok, for arbitrary base space B . This parameterized input data holds interesting structure; of note is the discovery of monodromy in these bundles, a point in the persistence diagram might not come back to the same place while tracing out a closed loop in the base space. In this talk, we will introduce the concept of a canopy: a topological space with some additional structural data reminiscent of a bundle which stores the representatives of persistence classes over the parameterizing base space B . Canopies are particularly useful since they are well defined, even in the presence of monodromy. We show that for nice enough parameterized families of functions, we can construct such a canopy and give structure theorems for the types of issues that can give rise to monodromy.

Balancing Geometry and Density with Fermat Metrics: Graphs, Clustering, and Applications

Schedule: July 9 15:00-15:30 Room 538

James M Murphy

Tufts University, USA

Abstract:

The curse of dimensionality renders statistical and machine learning in high dimensions intractable without additional assumptions on the underlying data. We consider geometric models for data that allow for mathematical performance guarantees and efficient algorithms that break the curse. Specifically, this talk considers a family of data-driven metrics that balance between density and geometry in the underlying data, known as Fermat distances. We consider discrete graph operators based on these metrics and prove performance guarantees for clustering with them in the spectral graph paradigm. Fast algorithms based on Euclidean nearest-neighbor graphs are proposed and connections with continuum operators on manifolds are developed.

Learning Generative Models on Persistence Diagram Space via Policy-Induced Markov Processes

Schedule: July 9 14:30-15:00 Room 538

Farzana Nasrin

University of Tennessee Knoxville, USA

Co-Author(s): Farzana Nasrin and Ernesto Ugona

Abstract:

Persistence diagrams (PDs) are central objects in topological data analysis, capturing multiscale geometric structure in a stable and interpretable form. While statistical methods for analyzing collections of PDs are well developed, learning probability distributions on diagram space remains challenging due to variable cardinality and geometric constraints. We propose a generative framework for persistence diagrams based on stochastic dynamics on diagram space. Specifically, we construct Markov processes driven by local edit operations---addition, relocation, and deletion of points---combined with projection mechanisms that enforce diagram validity. We show that the resulting process is irreducible, aperiodic, and geometrically ergodic, and therefore admits a unique stationary distribution. To learn from data, we parameterize the transition dynamics via policies and design reward functions that approximate distributional discrepancies between the stationary distribution and empirical diagram distributions. This establishes a connection between policy optimization and distribution matching on non-Euclidean spaces. Experiments on synthetic and real datasets demonstrate that the proposed approach captures key structural properties of diagram distributions, including persistence statistics and rare topological events.

Autonomous Applications of Topologically-Informed Data Driven Analytics & Fusion

Schedule: July 7 16:30-17:00 Room 538

Paul T Schrader

Air Force Research Laboratory (AFRL), USA

Co-Author(s): Paul T. Schrader

Abstract:

This decade's 'digital wild' is inundated with high rate, voluminous combinations of physics- and human-based data. The challenge is further exacerbated by rapidly accelerating autonomous architectures lacking explainability, compromised/poisoned heterogeneous data, and managing denied/degraded/intermittent/low-bandwidth environments. These and other prohibitive symptoms weaken user certainty while concurrently increasing compute complexities and reducing edge processing compatibility, resulting in failed support of (near) real-time decision speed. Addressing these challenges motivates rigorous scientific creativity through multi-disciplinary approaches, particularly leveraging the rich mathematical properties of a network's upstream data and their fused aggregates. Computational and algebraic topology implemented by topological data analysis (TDA), both classical and emerging, provide access to these properties and a path to modality/model agnostic fusion. This talk exhibits one such ongoing success, an efficient and scalable TDA Machine Learning (TDAML) algorithm and examines several case studies recently developed including applications in surveillance, time-series forecasting, data assurance, and materials/systems inspection. After a brief overview introducing TDA, an overarching dissection of the TDAML along with a survey of its initial object detection/classification studies and emerging implementation family are presented. Finally, future directions are discussed for the TDAML leveraging arbitrary physics- and human-based data analytics/fusion towards reliable and deployable situational/state/systems/material/cyber awareness. Distribution Statement A. Approved for public release: distribution is unlimited. AFRL-2026-0970.

Using topology to inform embedding

Schedule: July 8 17:30-18:00 Room 538

Michael Small

University of Western Australia, Australia

Co-Author(s): Eugene Tan

Abstract:

Embedding via time delay reconstruction is a fundamental step in reconstructing deterministic dynamical systems from time series data. In this talk I will review two techniques, due to topological data analysis (TDA) that allow one to better construct a time delay embedding and to evaluate performance of models of dynamics in that reconstructed space. First, TDA is used to select a geometrically tuned value of time delay for the reconstruction. Second, TDA applied to reconstructed attractors will be used to provide a metric to evaluate model performance. Time permitting I will introduce new methods to use information theory to optimise the modelling process with reservoir computing.

Relative commutative algebra of multigraded modules

Schedule: July 9 18:30-19:00 Room 538

Anastasios Stefanou

University of Bremen, Germany

Co-Author(s): Fritz Grimpen, Matthias Orth

Abstract:

A fundamental problem in applied algebraic topology is the efficient computation of minimal presentations and minimal free resolutions of homology modules arising from multigraded torsion-free complexes. While substantial progress has been made in the bigraded setting, the general multigraded case remains largely open. After a brief introduction to the algebraic framework of applied algebraic topology, I will present joint work with Fritz Grimpen on the construction and minimization of free--injective presentations of multigraded modules. I will then discuss ongoing work with Matthias Orth and Fritz Grimpen on developing relative Groebner basis techniques for submodules of quotients of free modules, and in particular for submodules of injective modules. These methods provide new tools for computing minimal resolutions of such modules, including, as special cases, modules given either as homology of chain complexes or via free--injective presentations.

Topological model selection: a case-study in tumour-induced angiogenesis

Schedule: July 8 14:30-15:00 Room 538

Bernadette Stolz

Max Planck Institute of Biochemistry, Germany

Co-Author(s): RA McDonald, HM Byrne, HA Harrington, T Thorne

Abstract:

Topological data analysis (TDA) offers powerful tools for studying biological phenomena. In this talk, I will present a recent application to spatial and dynamic biomedical data. Specifically, I will discuss a case study of topological model selection in tumour-induced angiogenesis, the process in which blood vessel networks are formed during tumour growth. While many mathematical models of tumour-induced angiogenesis exist, significant challenges persist in objectively evaluating and comparing their outputs. We develop a flexible pipeline for parameter inference and model selection in spatio-temporal models. Our pipeline identifies topological summary statistics which quantify spatio-temporal data and uses them to approximate parameter and model posterior distributions. We validate our pipeline on models of tumour-induced angiogenesis, inferring four parameters in three established models and identifying the correct model in synthetic test-cases.

Nested sequential inference for hotspots in noisy images with cubical persistent homology

Schedule: July 8 9:00-9:30 Room 538

Andrew M Thomas

University of Iowa, USA

Co-Author(s): Ranjan Maitra

Abstract:

Given an image that primarily consists of noise, one may wish to perform segmentation of the image into regions of signal deemed "hotspots". Of equal importance is quantifying the statistical significance of each of these estimated hotspots, also known as peaks or regions of interest. In this paper, we develop a topological data analysis method---which we deem "imphr"---to sequentially estimate hotspots and assess the statistical significance of each subsequent noise hypothesis in the image domain outside the union of the iteratively identified regions of interest. Our method employs newly developed advanced statistical methodology from the sequential testing and selective inference literatures to ensure both a highly rigorous and computationally efficient algorithm. We apply said algorithm to simulated data, and compare it with various methods for hotspot detection and spatial clustering in the literature; we also demonstrate its performance on real-world vibrothermography and fMRI data. In sum, the imphr algorithm not only provides rigorous theoretical guarantees and estimated hotspots with meaningful topology, but also yields performance as good and in many cases better than existing methods.

Using Persistent Homology to Analyze Access to Heterogeneous-Quality Resources and Heterogeneous-Severity Nuisances

Schedule: July 7 17:00-17:30 Room 538

Sarah Tymochko

College of the Holy Cross, USA

Co-Author(s): Gillian Grindstaff, Abigail Hickok, Jerry Luo, Mason Porter

Abstract:

Ideally, all public resources (e.g. hospitals, grocery stores, vaccination clinics, etc.) should be distributed in a way that is fair and equitable to everyone. However, this is not always the case. Quantifying how much (or little) access individuals have to certain resources is a complex problem. Previous work has shown that tools from topological data analysis (TDA) can be useful in determining holes in the locations of resource locations based on geographic locations and travel times [Hickok et al., Persistent homology for resource coverage: a case study of access to polling sites, SIAM Review, 2024]. Some resources may necessitate incorporation a notion of quality. We develop a framework for studying the coverage of resources of heterogeneous quality. As a case study, we look at public parks to determine how equitably green space is distributed. This topological framework for studying the coverage heterogeneous resources can be extended in many application areas. For example, it could be used to analyze the coverage of nuisances, or sites that one wants to avoid.

TDA-driven parameter inference in an agent-based model of zebrafish patterns

Schedule: July 8 15:30-16:00 Room 538

Alexandria Volkening

Purdue University, USA

Co-Author(s): Yue Liu

Abstract:

Many natural and social phenomena involve individual agents coming together to create group dynamics, whether the agents are drivers in a traffic jam, cells in a developing tissue, or locusts in a swarm. Here I will focus on the example of pattern formation in zebrafish, which are named for their dark and light stripes. Mutant zebrafish, on the other hand, feature different skin patterns, including spots and labyrinth curves. All of these patterns form as the fish grow due to the interactions of tens of thousands of pigment cells, making agent-based models a natural approach for describing cell behavior. However, stochastic, microscopic models are often not analytically tractable using traditional techniques, and parameter inference in biologically detailed, spatial agent-based models faces significant challenges. With this motivation, here I will describe how we are combining techniques from topological data analysis and approximate Bayesian inference to quantify structure in messy, cell-based patterns and infer parameter values.

Topological decoding of grid cell activity via path lifting to covering spaces

Schedule: July 8 15:00-15:30 Room 538

Iris Yoon

Wesleyan University, USA

Co-Author(s): Jared Yao

Abstract:

High-dimensional neural activity often reside in a low-dimensional subspace, referred to as neural manifolds. Grid cells in the medial entorhinal cortex provide a periodic spatial code that are organized near a toroidal manifold, independent of the spatial environment. Due to the periodic nature of its code, it is unclear how the brain utilizes the toroidal manifold to understand its state in a spatial environment. We introduce a novel framework that decodes spatial information from grid cell activity using topology. Our approach uses topological data analysis to extract toroidal coordinates from grid cell population activity and employs path-lifting to reconstruct trajectories in physical space. The reconstructed paths differ from the original by an affine transformation. We validated the method on both continuous attractor network simulations and experimental recordings of grid cells, demonstrating that local trajectories can be reliably reconstructed from a single grid cell module without external position information or training data. These results suggest that co-modular grid cells contain sufficient information for path integration and suggest a potential computational mechanism for spatial navigation.

Topological optimization with birth and death cochains

Schedule: July 7 18:30-19:00 Room 538

Ling Zhou

Duke University, USA

Co-Author(s): Thomas Weighill

Abstract:

We introduce the notion of birth and death cochains as generalized versions of birth and death simplices in persistent cohomology. We show that birth and death cochains (unlike birth and death simplices) are always unique for a given persistent cohomology class. We use birth and death cochains to define birth and death content as generalizations of birth and death times. We then demonstrate the advantages of using that birth and death content as loss functions on a variety of topological optimization tasks with point clouds, time series and scalar fields. We close with a novel application of topological optimization to a dataset of arctic ice images.

Special Session 123 : Nonlinear phenomena in elliptic and parabolic equations

Organizer(s): Futoshi Takahashi , Bernhard Ruf , Daisuke Naimen

Introduction: Recent advances in the analysis of qualitative properties of solutions to nonlinear elliptic and parabolic equations will be focused in this Special Session. Topics which will be discussed are: existence, non-existence, uniqueness, non-uniqueness and multiplicity of solutions, as well as asymptotic behavior, blow-up, singularity formation and bubbling phenomena. Special attention will be given to the use of critical and limiting inequalities as a fundamental tool to refine the understanding of nonlinear equations. Indeed, the analysis of these equations within the Calculus of Variations is profoundly related to the development of sharp inequalities describing subtle relations between functional spaces. Main goal of this Special Session is to encourage vital discussions between researchers from Real Analysis and PDEs, fostering collaborations and connections.

Critical norm blow-up rates for the energy supercritical nonlinear heat equation

Schedule: July 7 9:30-10:00 Room 619

Tobias Barker

University of Bath, England

Co-Author(s): Hideyuki Miura and Jin Takahashi

Abstract:

We study the behavior of the scaling critical Lebesgue norm for blow-up solutions to the nonlinear heat equation (the Fujita equation). For the energy supercritical nonlinearity, we give estimates of the blow-up rate for the critical norm.

LOW REGULARITY RESULTS FOR DEGENERATE POISSON PROBLEMS

Schedule: July 6 17:00-17:30 Room 619

Marta Calanchi

Università degli Studi di Milano, Italy

Co-Author(s): M. GROSSI

Abstract:

We study the Poisson problem,

$$\begin{cases} -\operatorname{div}(d^\beta \nabla u) = f & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

where $\Omega \subset \mathbb{R}^N$, $N \geq 2$ is a smooth bounded domain, f is a continuous function, $\beta < 1$, and $d(x) = \operatorname{dist}(x, \partial\Omega)$. We describe the behaviour of u near $\partial\Omega$ and discuss some of its regularity properties.

Existence of multi-bubbling solutions for a critical Hartree type equation

Schedule: July 6 14:30-15:00 Room 619

Daniele Cassani

University of Insubria & RISM, Italy

Abstract:

We consider the following equation

$$-\Delta u = K(|x'|, x'') \left(|x|^{-\alpha} * K(|x'|, x'') |u|^{2_\alpha^*} \right) |u|^{2_\alpha^*-2} u$$

in $\mathbb{R}^N$, where $N \geq 5$ and 2_α^* is the so-called upper critical exponent in the Hardy-Littlewood-Sobolev inequality and $K(|x'|, x'')$ with $(x', x'') \in \mathbb{R}^2 \times \mathbb{R}^{N-2}$, is bounded and non-negative. Under proper assumptions on the potential function K , we obtain the existence of infinitely many solutions for the nonlocal critical equation by using a finite dimensional reduction argument and local Pohozaev identities. It is a remarkable fact that the order α of the Riesz potential influences the existence/non-existence of solutions.

Uniform boundedness of solutions for superlinear heat equations

Schedule: July 6 17:30-18:00 Room 619

Yohei Fujishima

Shizuoka University, Japan

Co-Author(s): Toru Kan

Abstract:

We study the L^∞ estimates of radially symmetric solutions for a superlinear heat equation with the Dirichlet boundary condition, and show the uniform boundedness of global solutions. In particular, our results are applicable for nonlinear terms growing extremely faster than the exponential function when the space dimension is greater than 2 and smaller than 10.

Recent progress on the study of solutions to nonlinear Dirac equations

Schedule: July 6 15:30-16:00 Room 619

Qi Guo

Renmin University of China, Peoples Rep of China

Co-Author(s): Pan Chen, Yanheng Ding, Xiaojing Dong, Huayang Wang, Yuanyang Yu

Abstract:

In this talk, I will begin with a brief review of physical and geometric background of the Dirac operator, along with the spectral structure and orthogonal decomposition. Then I will introduce the definitions of action and energy ground states of nonlinear Dirac equations and discuss key properties such as existence, nonrelativistic limits, and convergence rates.

A system of superlinear elliptic equations in a cylinder

Schedule: July 6 18:00-18:30 Room 619

Yanyan Guo

Central China Normal University, Peoples Rep of China

Co-Author(s): Bernhard Ruf, Shuangjie Peng

Abstract:

This talk concerns with the existence of positive solutions of a coupled semi-linear elliptic system defined in a cylinder. The system couples an equation defined in the whole cylinder Ω with another equation defined at the bottom of the cylinder $\Omega' \times \{0\}$. We provide a priori L^∞ bounds for all positive solutions of the system when the nonlinear terms satisfy certain growth conditions. Using the a priori bounds and topological arguments, we prove the existence of positive solutions for these particular semi-linear elliptic systems.

Vanishing phenomena for Trudinger-Moser Inequalities with a scale parameter

Schedule: July 7 16:30-17:00 Room 619

Masato Hashizume

The University of Osaka, Japan

Abstract:

We consider the Trudinger-Moser inequality on a bounded domain with a scale parameter. We investigate the asymptotic behavior of maximizers attaining the inequality, with respect to the parameter. We first show that this behavior depends on the exponent in the Trudinger-Moser functional. When the exponent is large, an energy concentration phenomenon occurs, whereas when it is small, a vanishing phenomenon occurs. We then focus on the vanishing phenomenon and establish the asymptotic expansion of the optimal constant, as well as the profile of maximizers exhibiting vanishing behavior. Furthermore, we show that, after a suitable transformation, the maximizers converge to a maximizer of a L^2 -normalized variational problem.

Global existence at the critical mass for the two-dimensional fully parabolic Keller--Segel system

Schedule: July 6 18:30-19:00 Room 619

Tatsuya Hosono

Osaka Metropolitan University, Japan

Abstract:

We study the Cauchy problem for the two-dimensional fully parabolic Keller--Segel system at the critical mass. Global-in-time existence at the critical mass is known under radial symmetry or under additional moment assumptions on the initial data. A common approach in the literature is to impose such conditions, as they provide effective control of the behavior of solutions at spatial infinity. However, these assumptions are extrinsic to the intrinsic scaling structure underlying the critical mass phenomenon. In the absence of moment conditions, classical energy-based methods cease to be effective, and the problem becomes considerably more delicate at the critical threshold due to the degeneracy of the underlying energy structure. In this talk, we establish global-in-time existence for initial data at the critical mass without imposing any additional assumptions. The proof relies on a reconstructed Lyapunov functional and refined dissipative estimates that recover sufficient control of the dynamics in the whole space.

Bifurcating solutions of a Hartree-type elliptic equation

Schedule: July 6 14:00-14:30 Room 619

Yoshitsugu Kabeya

Osaka Metropolitan University, Japan

Co-Author(s): Vitaly Moroz (Swansea University, UK) and So Maeda (Nara Kita Senior High School, Japan)

Abstract:

We consider a Hartree-type elliptic equation (having the convolution of the unknown function) and discuss the existence of bifurcating solutions from the trivial solutions.

Fundamental solution and diffusion limits for the heat equation in a half-space with a diffusive dynamical boundary condition

Schedule: July 6 15:00-15:30 Room 619

Tatsuki Kawakami

Ryukoku University, Japan

Co-Author(s): Kazuhiro Ishige, Sho Katayama

Abstract:

In this talk, we derive an explicit representation of the fundamental solution to the heat equation in a half-space with a diffusive dynamical boundary condition, and establish sharp pointwise upper and lower bounds. We also investigate qualitative properties of the associated solutions, including precise decay estimates. Furthermore, we analyze the diffusion limits of solutions to the initial-boundary value problem and clarify the role of the diffusive dynamical boundary condition in determining their behavior. This talk is based on joint work with Prof. K. Ishige (University of Tokyo) and Dr. S. Katayama (Keio University).

On self-similar solutions of time-fractional semilinear heat equations

Schedule: July 7 9:00-9:30 Room 619

Mizuki Kojima

Kanagawa University, Japan

Abstract:

We consider self-similar solutions of semilinear heat equations involving the Caputo type fractional derivative with respect to time. We mainly investigate some properties of radially symmetric self-similar solutions. In particular, the solution can have a singularity at the origin under certain situation, which is specific to the time-fractional equation.

Solvability of the Cauchy problem for the porous medium equation with singular initial data

Schedule: July 7 8:00-8:30 Room 619

Nobuhito Miyake

Faculty of Mathematics, Kyushu University, Japan

Co-Author(s): Kazuhiro Ishige, Ryuichi Sato

Abstract:

We consider the solvability of the Cauchy problem for the porous medium equation with a power-type nonlinearity. More precisely, we establish a sufficient condition on the initial data for the existence of solutions in terms of uniformly local Morrey-type spaces. As an application, we identify the optimal singular profile of the initial data for solvability. This talk is based on the joint work with Kazuhiro Ishige (the University of Tokyo) and Ryuichi Sato (Iwate University).

Non-uniqueness of positive solutions for supercritical semilinear heat equations without scale invariance

Schedule: July 6 16:30-17:00 Room 619

Yasuhito Miyamoto

The University of Tokyo, Japan

Co-Author(s): Kotaro Hisa

Abstract:

We establish nonuniqueness of solutions for Cauchy problems of semilinear heat equations with a wide class of nonlinearities. Specifically, we consider

$$\left\{ \begin{array}{l} \partial_t u - \Delta u = f(u), \quad x \in \mathbf{R}^N, \quad t > 0, \quad u(x, 0) = u_0(x), \quad x \in \mathbf{R}^N, \end{array} \right.$$

where $N > 2$. We assume that the growth rate of f is less than the Joseph-Lundgren exponent for $N > 10$ and it satisfies certain assumptions guaranteeing a positive radial singular stationary solution u^* . We prove that if $u_0 = u^*$, then the problem has at least two positive solutions, namely u^* and $u(t)$ which satisfies $u(t) \in L_{loc}^\infty(0, t_0; L^\infty(\mathbf{R}^N))$ for some $t_0 > 0$ and

$$u(t) \rightarrow u^* \quad \text{in } L_{ul}^\gamma(\mathbf{R}^N) \quad \text{as } t \rightarrow 0^+$$

Ground states of a nonlocal variational problem and Thomas-Fermi limit for the Choquard equation

Schedule: July 6 13:30-14:00 Room 619

Vitaly Moroz

Swansea University, Wales

Co-Author(s): Damiano Greco, Zeng Liu, Yanghong Huang

Abstract:

We study nonnegative optimizers of a Gagliardo-Nirenberg type inequality that interpolates between the nonlocal Riesz energy and two L^q -norms. A particular case of the equivalent problem has been studied in connection with the Keller-Segel diffusion-aggregation models over the past few decades. The more general case considered in our work arises in the study of the Thomas-Fermi limit regime for the Choquard equations with local repulsion. We establish, for the first time, the optimal ranges of parameters for the validity of the above interpolation inequality, discuss the existence and qualitative properties of the nonnegative maximisers, and in some special cases estimate the optimal constant. In special cases it is known that the maximisers are Hölder continuous and compactly supported in a ball. We show that, depending on the regime, maximisers may also be smooth functions supported on the entire space, or discontinuous functions consisting of the characteristic function of a ball and a nonconstant, nonincreasing Hölder continuous function supported on the same ball. We use these qualitative properties of the maximisers to justify the validity of the Thomas-Fermi approximations for the Choquard equations with local repulsion. The results are verified numerically through extensive examples.

Polyharmonic Steklov eigenvalue problems

Schedule: July 7 13:30-14:00 Room 619

Michiaki Onodera

Institute of Science Tokyo, Japan

Abstract:

This talk concerns the spectral properties of polyharmonic Steklov eigenvalue problems on bounded domains. In particular, we will discuss the positivity of the first eigenfunction, which is nontrivial for higher-order elliptic problems due to the lack of a general maximum principle. This talk is based on joint work with Masato Hashizume and Nobuhito Miyake.

An Orlicz space approach to exponential elliptic problems

Schedule: July 7 8:30-9:00 Room 619

Federica Sani

University of Modena and Reggio Emilia, Italy

Co-Author(s): Alberto Boscaggin (University of Torino), Francesca Colasuonno (University of Torino), Benedetta Noris (Politecnico di Milano)

Abstract:

In this talk, we present a variational approach to semilinear elliptic problems with exponential nonlinearities in (possibly unbounded) annular domains of $\mathbb{R}^N$. These problems present significant analytical difficulties in dimensions $N \geq 3$, where the classical Sobolev framework is not sufficient to handle nonlinear terms with exponential growth. To overcome these difficulties, we combine tools from Orlicz space theory (which provide a natural functional setting to handle non-polynomial nonlinearities) with nonsmooth critical point methods in the spirit of Szulkin. This approach allows us to recover a suitable variational structure despite the lack of standard compactness properties. Under suitable structural assumptions, we establish the existence of positive solutions that are not radially symmetric, thereby exhibiting symmetry-breaking phenomena for this class of elliptic problems.

Deficit estimates for an entropic form of Gagliardo-Nirenberg inequalities via nonlinear parabolic equations

Schedule: July 7 15:30-16:00 Room 619

Takeshi Suguro

Kumamoto University, Japan

Abstract:

We consider several types of Gagliardo--Nirenberg inequalities. The functional inequalities can be expressed in terms of the Tsallis entropy, a one-parameter extension of the Boltzmann--Shannon entropy. In this talk, we obtain deficit estimates for the inequalities by using properties of solutions to nonlinear parabolic equations corresponding to the Tsallis entropy.

Fokker--Planck equations and n--dimensional Poincar\'e inequalities for isotropic densities

Schedule: July 7 14:00-14:30 Room 619

Elide Terraneo

University of Milan, Italy

Co-Author(s): G. Furioli (Univ. of Bergamo, Italy), A. Pulvirenti and G. Toscani (Univ. of Pavia, Italy)

Abstract:

We consider some n-dimensional functional inequalities of the type of Poincar\'e, with weight, for isotropic probability densities. Unlike previous studies, for example by S.G. Bobkov, and M. Ledoux (Ann. Probab. 37 (2009)), the derivation of these inequalities is strongly related to their connection with the problem of convergence to equilibrium for a class of Fokker--Planck type equations characterized by a variable coefficient of diffusion. This is a result obtained in collaboration with G. Furioli (Univ. of Bergamo, Italy), A. Pulvirenti and G. Toscani (Univ. of Pavia, Italy).

Co-rotating nearly parallel helical vortices of 3D incompressible Euler equations in infinite cylinders

Schedule: July 7 15:00-15:30 Room 619

Jie Wan

Beijing Institute of Technology, Peoples Rep of China

Abstract:

In this talk, we consider the existence of traveling-rotating helical vortices to 3D incompressible Euler equations in infinite cylinders, whose support sets consist of helical tubes with small cross-sections of radius $O(\varepsilon)$ and concentrate near several types of co-rotating helical solutions of nearly parallel vortex filaments model as $\varepsilon \rightarrow 0$, which justify the result in Klein, Majda and Damodaran [1995, JFM] and generalize results in Guerra and Musso [2026, Math Ann]. The key is to find clustered solutions to a semilinear elliptic equations in divergence form
$$\begin{cases} -\varepsilon^2 \operatorname{div}(K(x)\nabla u) = (u - q|\ln \varepsilon|)^p_+ & \text{in } \Omega, \\ u = 0 & \text{on } \partial\Omega \end{cases}$$
 for small values of ε . This is a joint work with Prof. Daomin Cao.

Special Session 124 : Mathematical methods for heterogeneous media

Organizer(s): José Matias , Ana Cristina Barroso , Elvira Zappale

Introduction: In this session, we intend to bring together specialists focused on the mathematical formulation and analysis of problems arising in the study of heterogeneous media. In a strict sense, all materials exhibit heterogeneity at some scale, and the specific characteristics of their microstructures significantly influence a wide range of their macroscopic properties. Addressing problems within this broad context naturally bridges Mathematics, Continuum Mechanics, and Materials Science. This interdisciplinary approach not only fosters the development of novel analytical and computational techniques but also requires the exploration of diverse functional spaces.

Riesz fractional gradient functionals defined on partitions: Nonlocal-to-local variational limits

Schedule: July 9 8:30-9:00 Room 434

Stefano Almi

University of Naples Federico II, Italy

Co-Author(s): Maicol Caponi, Manuel Friedrich, Francesco Solombrino

Abstract:

We address the asymptotics of functionals with linear growth depending on the Riesz s -fractional gradient on piecewise constant functions. We consider a general class of varying energy densities and we characterize their local limiting functionals in the sense of Gamma-convergence.

The effect of almost-periodic microstructures in phase separation

Schedule: July 9 9:00-9:30 Room 434

Riccardo Cristoferi

Radboud University, Netherlands

Co-Author(s): Lorenza D'Elia

Abstract:

Many of the new media needed by, and sought for, in the applications are heterogeneous materials. Being able to describe and predict stable equilibrium configurations of phases is thus fundamental in order to take full advantages of these materials. In this talk we will work within the gradient theory of phase separations, namely using a van der Waals-Cahn-Hilliard type of energy. We consider the case where the material has a microstructures that can be described by an almost-periodic function. This is intended to model quasi-crystalline materials, whose properties are in between periodic and random materials. We will discuss the effect of these types of microstructures in the sharp interface limit of the energy. This work is in collaboration with Lorenza D'Elia (TU Wien).

Homogenization in magnetoelasticity under small elastic response

Schedule: July 9 9:30-10:00 Room 434

Lorenza D'Elia

TU Wien, Austria

Abstract:

In this talk, we perform a simultaneous homogenization and linearization analysis for a magnetoelastic energy functional featuring a mixed Eulerian-Lagrangian structure. Neglecting Zeeman and anisotropic contributions, we characterize the asymptotic behaviour in the sense of Γ -convergence for the sum of a nonlinear magnetoelastic energy, a symmetric exchange term defined on the actual configuration, and for the associated magnetostatic self-energy. This is a joint work with M. Cherdantsev (Cardiff University), E. Davoli (TU Wien) and S. Ricciotti (TU Wien).

Effective transmission through an interface with evolving microstructure

Schedule: July 9 14:00-14:30 Room 434

Lucas M Fix

University of Augsburg, Germany

Co-Author(s): Gianna Goetzmann, Malte A. Peter, Jan-F. Pietschmann

Abstract:

We study the asymptotic behaviour of a system of nonlinear reaction--diffusion--advection equations in a domain consisting of two bulk regions connected via microscopic channels distributed within a thin membrane. Both the width of the channels and the thickness of the membrane are of order $\varepsilon \ll 1$, and the geometry evolves in time in an a priori known way. We consider nonlinear flux boundary conditions at the lateral boundaries of the channels and critical scaling of the diffusion inside the layer. Extending the method of homogenisation in domains with evolving microstructure to thin layers, we employ two-scale convergence and unfolding techniques to derive an effective model in the limit $\varepsilon \rightarrow 0$, in which the membrane is reduced to a lower-dimensional interface. We obtain jump conditions for the solution and the total fluxes, which involve the solutions of local, space--time-dependent cell problems in the reference channel.

Variational models for material voids

Schedule: July 9 14:30-15:00 Room 434

Manuel Friedrich

JKU Linz, Austria

Abstract:

In this talk, I present variational models for materials with voids in both geometrically linear and nonlinear elasticity. Specifically, we consider functionals featuring elastic bulk terms and a surface contribution proportional to the surface area of the voids within the material. We first discuss a relaxation result that leads to an additional surface term related to the phenomenon of collapsing voids. We then present an application to the derivation of effective homogenization limits for heterogeneous materials.

Relaxation of variational models for multiphase elastoplastic materials

Schedule: July 9 15:00-15:30 Room 434

Carolin Kreisbeck

KU Eichstätt-Ingolstadt, Germany

Co-Author(s): Elisa Davoli, Samuele Ricco

Abstract:

The coupling of phase transitions in shape memory alloys with plastic deformation induces intricate microstructure formation and gives rise to highly nonconvex energy functionals. In this talk, we study a class of variational models arising in single-slip finite crystal plasticity. In contrast to classical settings with a single elastic well, the elastic energy features two wells, leading to interactions between the slip system and the elastic phases under different compatibility constraints. To better understand the effective deformation behavior of these models, we analyze their relaxation, with focus on the quasiconvexification of the underlying extended-valued energy densities. After identifying the quasiconvex hull of the admissible deformation gradients, which shows that the effective states can vary within a range of volumetric responses, we derive bounds on the quasiconvex envelope from above and below. The upper bounds on the rank-one convex envelopes require careful constructions of suitable rank-one lines, while the established polyconvex lower bounds are generally smaller, but are shown to be optimal in a special case.

Variational analysis for the nonlinear elastic energy induced by edge dislocations: the dilute regime

Schedule: July 9 13:30-14:00 Room 434

Lucia De Luca

IAC-CNR Roma, Italy

Abstract:

We introduce nonlinear semi-discrete and discrete models for the elastic energy induced by a finite system of edge dislocations in two dimensions. We analyze the asymptotic behavior of the nonlinear elastic energy, as the lattice spacing (in the purely discrete model) and the core-radius (in the semi-discrete framework) vanish. We work within the dilute regime, corresponding to a finite number of effective singularities. Joint work with Roberto Alicandro, Giuliano Lazzaroni, Mariapia Palombaro, Marcello Ponsiglione.

Membranes in nonlocal hyperelasticity

Schedule: July 9 15:30-16:00 Room 434

Anastasia Molchanova

TU Wien, Austria

Co-Author(s): Dominik Engl, Hidde Schönlberger

Abstract:

Motivated by the analysis of thin structures, we study the variational dimension reduction of hyperelastic energies involving nonlocal gradients to an effective membrane model. When rescaling the thin domain, initially isotropic interaction ranges naturally become anisotropic, which leads us to develop a theory of anisotropic nonlocal gradients with direction-dependent interaction ranges. In contrast to existing nonlocal derivatives with finite horizon, which are typically defined via interaction kernels supported on balls of positive radius, our formulation employs ellipsoidal interaction regions whose principal radii may vanish independently. This yields a unified framework interpolating between fully nonlocal, partially nonlocal, and purely local models. Using these tools, we establish a Γ -convergence analysis for the associated nonlocal thin-film energies. The limit functional retains the structural form of the classical membrane energy, and the classical local model is recovered exactly when all interaction radii vanish. This talk is based on joint work with Dominik Engl and Hidde Schönlberger.

Variational formulation of planar linearized elasticity with incompatible kinematic

Schedule: July 9 16:30-17:00 Room 434

Marco Morandotti

Politecnico di Torino, Italy

Co-Author(s): Pierluigi Cesana and Edoardo Fabbrini

Abstract:

We address mechanical equilibrium in the planar strain regime for systems with incompatible kinematic from a variational standpoint. We show that, for non-simply connected domains, the equilibrium problem for a non-liftable strain-stress pair can be reformulated as a well-posed minimization problem for the Airy potential. We characterize the additional compatibility conditions on the internal boundaries of the domain as Volterra dislocations or disclination. Finally, we establish that the minimization problem for the Airy potential can be reduced to a finite-dimensional optimization involving cell formulas.

Dynamics of screened particles towards equispaced ground states and applications to misfit dislocations

Schedule: July 9 17:00-17:30 Room 434

Marcello Ponsiglione

Sapienza, University of Roma, Italy

Abstract:

We analyse the dynamics - driven by the gradient flow of negative fractional seminorms - of empirical measures towards equispaced ground states. In particular, we prove the optimality of equispaced misfit dislocations at semi-coherent interfaces

Derivative-free descriptions of smoothness in variable exponent Sobolev spaces and generalized Orlicz-Sobolev spaces

Schedule: July 9 17:30-18:00 Room 434

Ana Margarida Ribeiro

NOVA School of Science and Technology (NOVA FCT), Portugal

Co-Author(s): R. Ferreira, P. Hasto, C. Kreisbeck, E. Zappale

Abstract:

Function spaces with spatially heterogeneous behaviour have become an important tool in modern analysis. In this talk, I will discuss derivative-free descriptions of smoothness in the framework of variable exponent and generalized Orlicz spaces. The approach considered has its origins in the work of Bourgain, Brezis and Mironescu [2002, J. Anal. Math.] where difference quotients were used to study classical Sobolev spaces. In the setting of variable exponent and generalized Orlicz spaces, difference quotients are no longer adequate. It will be shown that the averaging operator introduced by Diening and Hasto [2007, Studia Math.] to address the trace space appropriately captures the desired smoothness of functions in a variable exponent Sobolev space as well as in a generalized Orlicz-Sobolev space.

Sharp-interface limit for non-isothermal and nonlocal Modica-Mortola functionals

Schedule: July 9 18:00-18:30 Room 434

Emanuele Tasso

TU Wien, Austria

Co-Author(s): Elisa Davoli

Abstract:

In this talk, we analyze a non-isothermal and nonlocal variant of the Modica-Mortola diffuse model for phase transitions. Here the classical gradient penalization is replaced by a nonlocal singular perturbation and the double-well potential is space-dependent. Our main result is the identification of the sharp-interface limit as the width of the transition layers converges to zero. This is joint work with Elisa Davoli.

Homogenization of elasto-plastic plate equations

Schedule: July 9 18:30-19:00 Room 434

Igor Velcic

University of Zagreb, Faculty of Electrical Engineering and Computing, Croatia

Co-Author(s): Marin Buzancic, Elisa Davoli, Josip Zubrinic

Abstract:

Starting from $3d$ quasistatic evolution of perfect plasticity we discuss the model of $2d$ quasistatic evolution of perfect plasticity by doing simultaneous homogenization and dimension reduction. Depending on the ratio between the thickness of the plate and period of the oscillations of the material we obtain different models in the limit and discuss the effective plastic dissipation potential at the interface of the different phases of the material.

Special Session 125 : Models of Fluid Motion

Organizer(s): John Carter , Mats Ehrnstrom , Panayiotis Panayotaros

Introduction: In this special session, we explore models for the complex behavior of fluid flow based on the Euler or Navier-Stokes equations. Our focus lies on approximate models where nonlinearity, dispersion, and other effects are important. A diverse group of speakers (in terms of experience, geographic location, and gender) will present recent analytical, numerical, and experimental results based on linear, nonlinear, and nonlocal differential equation models.

The spectrum of steady, laser-driven convective flows

Schedule: July 9 17:00-17:30 Room 436

Benjamin Akers

The Air Force Institute of Technology, USA

Co-Author(s): Benjamin Akers, Jeremiah Lane, Wesley Coonradt

Abstract:

It has recently been shown that continuous wave lasers can generate steady, parametrically-analytic, laser-driven convective fluid flows (Lane, Fluids 2021), (Lane Stud. App. Math. 2024). We investigate the stability of these flows, by calculating their spectral data. Steady internally forced convection is contrasted to classic Rayleigh-Bernard convection. The spectrum is shown to be parametrically analytic at simple eigenvalues. The spectral data of large amplitude flows are computed, and dynamics near unstable flows are presented.

From explicit formulas to Wave Kinetic theory for the Benjamin-Ono equation

Schedule: July 10 8:00-8:30 Room 436

Yvonne Alama Bronsard

Massachusetts Institute of Technology, USA

Abstract:

In this talk, we begin by introducing the explicit solution formula for the Benjamin-Ono (BO) equation obtained by Patrick Gerard. Building on this representation, we present an overview of recent numerical schemes, which provide new tools for investigating the long-time dynamics of BO. In the setting of randomized initial data, we then explain how iterating this explicit formula, combined with non-commutative Khintchine's inequality, yields new insights into the Wave Kinetic theory for BO, up to the physically relevant kinetic time scale. The former results are joint work with Xi Chen (Basel), Matthieu Dolbeault (Nantes), Thierry Laurens (Wisconsin-Madison), and Ola Maehlen (Paris-Saclay), while the latter is a joint work with Gigliola Staffilani (MIT) and Felipe Hernandez (Penn State).

Analytical frameworks for spatially quasiperiodic or uniformly local free-surface flows

Schedule: July 9 17:30-18:00 Room 436

David M. Ambrose

Drexel University, USA

Abstract:

We will present methods of existence theory for free-surface fluid flows in the case of uniformly local Sobolev data and in the case of spatially quasiperiodic initial data. These are both instances of non-decaying, non-periodic fluid flows. Such data could arise, for instance, when making a non-periodic perturbation of a periodic flow, or when wavetrains with different, non-commensurate periodicities interact. Among the topics to be discussed are a version of the Birkhoff-Rott integral and Hilbert transform which do not require decay or periodicity, and estimates for these in uniformly local Sobolev spaces. Another potential framework to be applied is the Cauchy-Kowalevski theorem, and some interesting consequences of this in the spatially quasiperiodic setting will be discussed.

Modeling Broadband Water-Wave Experiments with Generalizations of NLS

Schedule: July 9 13:30-14:00 Room 436

John Carter

Seattle University, USA

Co-Author(s): Joanna Van Liew and Diane Henderson

Abstract:

Water waves generated by storms gradually disperse, forming swells that can travel thousands of kilometers across the ocean's surface. The evolution of such swells on deep water can be modeled by the nonlinear Schrodinger (NLS) equation and its generalizations. However, most of these models assume a narrow range of wave frequencies and do not account for any form of energy loss. We compare predictions from new NLS generalizations that include dissipation and allow for broad ranges of frequencies with measurements from new laboratory experiments in which the frequency broadbandness was varied.

Following Information Flow in the Majda-McLaughlin-Tabak Model

Schedule: July 10 10:30-11:00 Room 436

Christopher Curtis

San Diego State University, USA

Co-Author(s): Erik Bollt

Abstract:

In this work, we quantify the timescales and magnitude of information flow associated with multiscale energy transfer in the Majda-McLaughlin-Tabak model. As we show, both forward and inverse cascade features are detected. However, our method allows for a more intricate picture to emerge which quantifies how wave mixing allows for widely disparate scales to be causally linked. This should be of use in a range of similar problems, and thus we present a method that, beyond canonical averaging techniques, provides a more detailed characterization of chaotic multiscale flows.

The Benjamin-Feir instability in KdV-like equations

Schedule: July 9 16:30-17:00 Room 436

Bernard Deconinck

University of Washington, USA

Co-Author(s): Bhavna Kaushik

Abstract:

Nonlinear waves in dispersive media can be susceptible to modulational instabilities. We examine a category of scalar equations, with general dispersion and monomial nonlinearity, including a large variety of KdV-like equations. For small-amplitude traveling wave solutions, we provide a complete characterization of the spectrum near the origin of the linear operator obtained from linearizing about periodic traveling waves. We prove rigorously that, when the modulational instability is present, the spectrum connected to the origin consists of curves that invariably form a closed figure-eight pattern.

Spectral Evidence of Integrability Breakdown in Shallow-Water Multisoliton Fission: A pIST Benchmark of Wave Models

Schedule: July 9 8:30-9:00 Room 436

Jose Galaz

Pontificia Universidad Catolica de Chile, Chile

Co-Author(s): Rodrigo Cienfuegos, Damyan Santander

Abstract:

We study the nonlinear Fourier spectrum of four shallow-water wave models --KdV, Serre-Green-Naghdi (SGN), Madsen-Sorensen, and Whitham-- using the periodic inverse scattering transform (pIST) of KdV as a spectral diagnostic, justified by a piecewise KdV-coupling approximation argument. Applying this framework to numerical simulations and laboratory data of multisoliton fission from Trillo et al. (Phys. Rev. Lett., 2016), we find that SGN best reproduces the KdV-theoretical soliton-spectrum amplitudes within 3-7% RMSE, yet all models exhibit substantially larger and increasingly variable errors against laboratory data, with up to 30-60% RMSE at the highest Ursell (Ur) numbers (84--26,000). This growing model-lab discrepancy is accompanied by a spatial drift of pIST soliton amplitudes along the channel, which would remain constant under perfect KdV integrability, providing direct spectral evidence of integrability breakdown driven by dissipation. We propose a physical conjecture for the dominant dissipation mechanism, supported by fitted power-law decay of pIST soliton amplitudes along the channel. These findings establish a spectral benchmark for shallow-water models and demonstrate that dissipation closures accounting for subtle energy losses are essential to capture multisoliton fission dynamics at high Ur .

Numerical Study of Boussinesq systems

Schedule: July 9 8:00-8:30 Room 436

Christian Klein

University Burgundy Europe/IMB, France

Co-Author(s): Vincent Duchenes, Theo Gaudry, Sergey Gavriluk, Jean-Claude Saut

Abstract:

We present a numerical study of solutions to equations appearing in the theory of surface waves, concretely Boussinesq systems (integrable and non-integrable examples) and Serre-Green-Naghdi (SGN) equations. Solitary waves in 1D are constructed, and their stability is studied numerically. The time evolution of localised initial data is explored. Of special interest is the role of the non-cavitation condition. The appearance of dispersive shock waves, zones of rapidly modulated oscillations, in the vicinity of shocks of the corresponding dispersionless systems is studied. In the context of the SGN equations, these questions are also addressed in 2D.

Transverse instability of line periodic waves to the KP-I type equations

Schedule: July 9 18:30-19:00 Room 436

Wei Lian

NTNU, Norway

Co-Author(s): Erik Wahlen

Abstract:

The passage from linear instability to nonlinear instability has been shown for 1D solitary waves under 2D perturbations. Although transverse instability of periodic waves to the KdV equation under the KP-I flow has been expected to be true from spectral instability for a long time, it has not been clear how to adapt the general instability theory for solitary waves to periodic waves until very recently. In this talk, we present how such an adaptation works with the aid of exponential trichotomies and an approximate scheme. Joint work with Erik Wahlen.

A variational construction of solitary waves for the Babenko equation on finite depth

Schedule: July 10 8:30-9:00 Room 436

JOHANNA MARSTRANDER

NTNU - Norwegian University of Science and Technology, Norway

Co-Author(s): Mats Ehrnstrom, Tomas Dohnal

Abstract:

We construct solitary waves for the two-dimensional steady water wave problem directly from the Babenko formulation in the case of pure gravity waves over finite depth. The proof is straight-forward in the sense that it is built on constrained minimization of a scalar nonlinear and nonlocal equation as in Weinstein (1987), and a limiting procedure from periodic waves as Ehrnström-Groves-Wahlén (2012), using concentration-compactness. The novelty lies not the least in the nonlocal cubic terms appearing in the Babenko variational formulation, which carry negative order, and make nonlinear harmonic analysis an important part of the proof. The constructed smooth and localised solutions of the Babenko equation correspond to smooth and localised free-surface waves in the two-dimensional steady water wave problem over a flat bed with gravity. We show that the Babenko solitary waves are approximated by scalings of the classical Korteweg-De Vries solitary waves.

Solitary Waves in a Two-Layer Fluid with a Free Surface

Schedule: July 9 18:00-18:30 Room 436

Dag Nilsson

Linnaeus University, Sweden

Co-Author(s): Mark Groves

Abstract:

We study two-dimensional internal travelling waves featuring both a free surface and an internal interface, propagating under the combined effects of gravity and surface and interfacial tension. By applying the method of spatial dynamics, the governing equations are reformulated as an infinite-dimensional dynamical system in which the unbounded spatial variable assumes the role of time:

$$u_x = Lu + N(u)$$

We focus on the special case in which the imaginary part of the spectrum of L consists of the eigenvalues $0, \pm i\kappa$, each with algebraic multiplicity two. A centre manifold reduction is then carried out, leading to a finite-dimensional system of reduced equations. At leading order, this reduced system takes the form of a coupled KdV-NLS system and we discuss the existence of homoclinic solutions of this system.

Mode interactions of surface gravity waves in triangular domains

Schedule: July 9 14:00-14:30 Room 436

Panayiotis Panayotaros

IIMAS, Universidad Nacional Autonoma de Mexico, Mexico

Co-Author(s): Eddaly Guerra Velasco, Boris A. Percino Figueroa, Rosa M. Vargas Magaña

Abstract:

We present a model of nonlinear mode interactions of 2-D gravity surface water waves in a domain with inclined lateral boundaries, assuming free surface potential flow. We consider an isosceles triangular domain with known linear modes and frequencies, and describe a preliminary analysis of the lowest nonlinear mode using normal forms. We also report on recent progress in the computation of linear modes and frequencies in more general triangular domains.

A new high-order shallow-water modeling approach: variational derivation and numerical simulations

Schedule: July 9 9:30-10:00 Room 436

Christos Papoutsellis

ECOLE NATIONALE DES PONTS ET CHAUSSEES, France

Co-Author(s): Christos Papoutsellis, Michel Benoit

Abstract:

We introduce a variational framework that generates a family of shallow-water wave models of increasing order of accuracy, unifying classical asymptotic long-wave theories with nonlocal Hamiltonian formulations. Starting from Luke's variational principle, we approximate the velocity potential using vertical polynomial ansatz motivated by the shallow-water structure of the underlying Dirichlet-to-Neumann operator. This construction leads to a hierarchy of models expressed in canonical variables, whose evolution equations preserve the canonical, nonlocal Hamiltonian structure of the full water-wave problem. In the case of uniform depth, we establish the equivalence with the Isebe--Kakinuma model and clarify connections with several classical and modern asymptotic models. We analyze the linear dispersion and stability properties of the resulting systems and validate the framework numerically through simulations of solitary-wave propagation and interactions. Finally, we extend the formulation to variable bathymetry and present results illustrating nonlinear wave--wave and wave--topography interactions.

Analysis of the adhesion model and reconstruction in cosmology

Schedule: July 10 11:30-12:00 Room 436

Robert Pego

Carnegie Mellon University, USA

Co-Author(s): Jian-Guo Liu

Abstract:

The adhesion model is a multidimensional model of mass transport in cosmology in a perturbed Einstein-de Sitter universe, which reduces to sticky particle flow in 1D. Velocity is given by a Hopf-Lax formula and concentrates mass on sheets, filaments and points, but it is known that momentum is not conserved in general. Work in the astronomy literature by Brenier, Frisch and collaborators relates the problem of reconstructing the primeval velocity distribution to an optimal mass transport problem. We carry out a mathematical analysis of the initial value problem, establishing a number of basic facts, including the uniqueness of a 'sticky' mass flow and a characterization of its absolutely continuous part in terms of a natural Monge-Ampère equation. We find that the singular part is not necessarily determined correctly by optimal transport, and this can result in inexact reconstruction.

(Down)shifting Paradigms in Water Waves: What Processes Drive the Spectral Shifts?

Schedule: July 9 15:00-15:30 Room 436

DANIEL J RATLIFF

Northumbria University, England

Co-Author(s): T.J. Bridges, O. Tritchenko

Abstract:

Despite centuries of study, there continue to be many open problems in dynamics of water waves. One such problem is that of frequency downshifting, a phenomenon in water waves where the spectral peak and/or mean of the wave spectra permanently moves downwards over the wave's evolution. Typically this phenomenon is argued to be primarily driven by dissipative processes such as wavebreaking, with energy loss being the only pathway to permanent spectral movement. However, recent work by the authors have demonstrated that this phenomenon can happen conservatively (i.e. without energy loss) and can be mediated by wave-mean flow interactions. Since both processes are shown to contribute to downshifting, and both are present within water wave problems, this provokes the natural question - how do they interact and contribute to the overall process of downshifting in water waves? This talk will start with an overview of downshifting from a wave-mean flow perspective in order to demonstrate how such a process mediates downshifting, by using a Benney-Roskes system to illustrate the fundamentals of the process. We will then introduce (simple) dissipative effects and explore how this impacts movements in the spectral peak as a function of nondimensional depth. Ultimately we find that deep into the modulationally unstable regime dissipation leads to more monotonic and narrow-banded downshifting than that driven by purely mean flow effects, suggesting that dissipation plays a long-term role in arresting the downshifting phenomena.

Physical-Space Models for Unidirectional Deep-Water Waves

Schedule: July 9 15:30-16:00 Room 436

Paivo Simson

Tallinn University of Technology, Estonia

Abstract:

We investigate unidirectional reductions of deep-water evolution equations without recourse to Fourier normal variables or complex canonical transformations. By closing the system entirely in terms of surface elevation, we obviate the need for velocity potential initial data, which is a significant advantage for simulating coherent structures such as breathers from experimental observations. The resulting non-local equations retain the exact linear dispersion relation and capture leading-order cubic nonlinearities. We show that both Hamiltonian and non-Hamiltonian models can be consistently formulated within this framework. Notably, lower-accuracy Hamiltonian variants reveal an unexpected integrable structure, while non-Hamiltonian versions achieve remarkable accuracy against fully nonlinear Euler computations up to moderate steepness. All models reduce to the nonlinear Schrodinger equation in the narrow-band limit with the correct deep-water coefficients.

Asymmetric Travelling Capillary-Gravity Waves

Schedule: July 10 9:00-9:30 Room 436

Douglas Svensson Seth

Norwegian University of Science and Technology, Sweden

Abstract:

Periodic travelling waves that solve the capillary-gravity Whitham equation have been fully characterised in the case of small and even waves. This characterisation is complemented by the work presented in this talk dealing with small asymmetric periodic travelling waves. Such asymmetric waves are far more scarce than the even ones and can only be constructed in certain cases for weak surface tension. The method also generalises in a straightforward way to a class of similar equations for which we either can prove the existence of or non-existence of asymmetric solutions. However, the proof relies on some technical calculations that are different for each equation. We note how this could be done for the Babenko equation, which is equivalent to the full water wave problem, to determine the existence of small amplitude Capillary-Gravity Waves.

Improved existence time for dispersive water waves equations

Schedule: July 10 9:30-10:00 Room 436

Nadia Skoglund Taki

University of Bergen, Norway

Co-Author(s): Benjamin Melinand, Didier Pilod, Sigmund Selberg, and Achenef Tesfahun

Abstract:

In this presentation, we will discuss techniques to improve the time of existence for dispersive water waves equations while keeping the small parameters (ϵ, μ) decoupled. The proofs rely on the energy method and new Strichartz estimates. These techniques are robust and can be adapted to several dispersive equations and systems. In the two-dimensional case, we exceed the time of existence of order ϵ^{-1} in the long wave regime, which appears to be new. The talk is based on joint work with Benjamin Melinand, Didier Pilod, Sigmund Selberg, and Achenef Tesfahun.

Soliton Turbulence in Non-integrable Systems

Schedule: July 9 9:00-9:30 Room 436

Marcelo V. Flamarion

Pontificia Universidad Catolica del Peru, Peru

Co-Author(s): Ekaterina Didenkulova and Efim Pelinovsky

Abstract:

We present a comparative study of the statistical properties of rarefied soliton gases within both integrable and non-integrable models from the Korteweg-de Vries (KdV) hierarchy. Focusing on multi-soliton solutions of the modified KdV equation and the modular Schamel equation, we show that bipolar soliton gases exhibit the formation of rogue waves, a feature absent in unipolar gases. This distinction is reflected in the evolution of higher-order statistics, with kurtosis increasing in the bipolar case and decreasing in the unipolar one. In integrable settings, the statistical characteristics relax to stationary states, whereas in non-integrable systems they remain time-dependent. We also observe inelastic energy transfer from smaller to larger solitons, leading to increasingly extreme wave events. The emergence of anomalously large structures, referred to as champion solitons, is discussed in the context of non-integrable dynamics.

Inertial particle transport under weakly modulated nearshore waves

Schedule: July 10 11:00-11:30 Room 436

Rosa Maria RM Vargas-Magana

University of Bergen, Norway

Abstract:

The ocean surface is intrinsically nonlinear, with resonant wave-wave interactions continuously shaping the wave field. As waves shoal toward the coast, dispersive effects weaken while nonlinearities become more strongly expressed. In this regime, weak-to-moderate amplitude modulation, spanning timescales from seconds to minutes, is readily observed in both Lagrangian and Eulerian measurements of the surface elevation. The transport of inertial particles within such wave fields remains a significant open problem in many disciplines. In this talk, we examine inertial particle trajectories under weakly modulated wave conditions representative of the nearshore zone. The dynamics reveal a clear two-scale structure: particles undergo oscillatory spiral motion at the carrier-wave frequency while simultaneously experiencing a slow back-and-forth drift governed by the group modulation. The amplitude, period, and net displacement of this drift depend sensitively on the modulation parameters and initial conditions. These findings reveal how the nonlinear group structure of nearshore waves regulates particle transport in ways not captured by current models, with direct implications for sediment transport, pollutant dispersion, and a more reliable assessment of the fate of buoyant material along coastlines.

Dynamics of inviscid ferrofluid jets: the Hamiltonian framework

Schedule: July 10 12:00-12:30 Room 436

Zhan Wang

Institute of Mechanics, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

This talk investigates the surface dynamics and stability of solitary waves on an inviscid ferrofluid jet. We begin by establishing a proof of the Hamilton principle for the axisymmetric system and deriving a unique homogeneous expansion of the Dirichlet-Neumann operator (DNO), offering a formulation distinct from that of Guyenne & Parau (2016). Within a unified Hamiltonian/Lagrangian framework, we introduce a systematic methodology for deriving reduced model equations across multiple scales. In particular, we propose a nonlinear model with full dispersion by truncating the DNO expansion at the cubic order. We demonstrate that this model accurately captures the speed-amplitude and speed-energy bifurcations inherent in the full Euler equations. Utilizing this reduced model, we examine the stability of solitary waves under longitudinal disturbances. Our findings indicate that stability exchange occurs at the stationary points of the speed-energy bifurcation curve, providing an axisymmetric parallel to the stability criteria established by Saffman (1985). Extensions of these results to the full Euler equations will be discussed as time allows.

Stability of damped wave equation

Schedule: July 9 14:30-15:00 Room 436

Runzhang Xu

Harbin Engineering University, Peoples Rep of China

Abstract:

In this talk, we are concerned with the description of global quantitative stability of wave equations with linear strong damping and linear or nonlinear weak damping. By giving some energy decay estimates, we obtain several conclusions about the continuous dependence of the global solution on the initial data and the coefficients of the strong damping term and linear or nonlinear weak damping term. This work also establishes a new idea to use the dissipative effect to obtain the better continuous dependence conclusions, which also reflect the dissipative properties of the solution.

Special Session 126 : Defects, Microstructures, and Failure: Multiscale Variational Models

Organizer(s): Leonard Kreutz , Konstantinos Zemas

Introduction: Understanding the failure behavior of materials remains one of the most compelling challenges at the intersection of mathematics, physics, engineering, and materials science. The macroscopic behavior of materials is profoundly influenced by the presence and interaction of defects and microstructures, which evolve across multiple scales and give rise to interesting scientific challenges. A comprehensive understanding of the interplay between macroscopic failure phenomena and structures at the meso- and microscale remains a central goal in applied mathematics. From a variational perspective, much of the research has focused on the introduction and rigorous analysis of appropriate energy functionals governing the physical behavior of the system under investigation. This session brings together leading researchers in applied mathematics--particularly, in the calculus of variations--and highlights such models, with emphasis on models of magnetic and elastic materials. Regarding magnetic materials, special attention will be given to localized, non-uniform spin textures, including magnetic skyrmions, skyrmionic bubbles, vortices, and chiral domain walls. In elasticity theory, the session will focus on understanding the mechanisms behind the emergence of material defects such as cracks, folds, and dislocations.

Nonlocal approximation of a Griffith-type energy

Schedule: July 8 17:00-17:30 Room 445

Stefano Almi

University of Naples Federico II, Italy

Co-Author(s): Elisa Davoli, Anna Kubin, Emanuele Tasso

Abstract:

We prove that De Giorgi's conjecture for nonlocal approximation of free discontinuity problems extends to the case of functionals defined in terms of the symmetric gradient of the admissible field. For a suitable class of continuous finite difference functionals, we show the compactness of deformations with equibounded energies, as well as their Gamma convergence. The compactness (and closure) analysis builds on a Fréchet-Kolmogorov approach and a novel characterization of GSBD.

Homogenization of the stochastic double-porosity model.

Schedule: July 8 14:00-14:30 Room 445

Elise Bonhomme

Universite de Bretagne Occidentale, France

Co-Author(s): Mitia Duerinckx, Antoine Gloria

Abstract:

In this talk, I will present joint work with Mitia Duerinckx and Antoine Gloria, in which we prove the homogenization of the so-called double-porosity model in a random setting where the resonant inclusions are not uniformly bounded nor separated. This mesoscopic model (used to describe flows in fractured porous media) is obtained as the limit of a diffusion process in a highly heterogeneous material made of two pure phases: a connected healthy phase (with conductivity of order 1) randomly perforated by a dense network of small inclusions of a second, nearly soft phase whose conductivity scales like the square of their size and tends to zero. In this specific regime, so-called resonance phenomena occur, in the sense that the homogenized model keeps memory of nontrivial interactions between the micro and macroscopic scales of the material.

Curvature-dependent cavitation energies

Schedule: July 7 18:00-18:30 Room 445

Marco Bresciani

Johannes Kepler University Linz, Austria

Co-Author(s): Carlos Mora-Corral, Fabian Rupp

Abstract:

The modeling of cavitation in nonlinear elastostatics typically rests upon the minimization of an energy functional comprising a bulk term, accounting for strain concentration, and a surface term proportional to the area of the cavity boundaries. Motivated by studies on void stability and the search for a regularizing effect, we propose a variational model featuring a surface term that depends on the curvature of the cavity boundaries. The rigorous formulation employs oriented varifolds on the deformed configuration and is based on a suitable coupling between these varifolds and the underlying deformation. Our main findings ensure the well-posedness of the resulting free-discontinuity problem and identify first-order necessary conditions for minimality.

Energy concentration in a two-dimensional magnetic skyrmion model

Schedule: July 7 15:00-15:30 Room 445

Luca Briani

Technical University of Munich, Germany

Co-Author(s): Marco Cicalese, Leonard Kreutz

Abstract:

In this talk, I present the formation of singularities in a chiral Skyrme-type energy model, which describes magnetic solitons in two-dimensional ferromagnetic systems. In the presence of a diverging anisotropy term, which enforces a preferred background state of the magnetization, I show how to establish a weak compactness result for the topological charge density and prove that it converges to an atomic measure with quantized weights. I characterize the Γ -limit of the energies as the total variation of this measure. Then, I consider the case of lattice-type energies and prove a corresponding compactness and Γ -convergence result. To this end, I will first carefully define a notion of discrete topological charge for S^2 -valued maps. This is a joint work with Marco Cicalese and Leonard Kreutz.

A fractional approach to strain-gradient theory for plasticity: beyond core-radius of discrete dislocations

Schedule: July 7 18:30-19:00 Room 445

Maicol Caponi

University of L'Aquila, Italy

Abstract:

In this talk we derive a strain-gradient theory for plasticity as the Γ -limit of discrete dislocation fractional energies, without the introduction of a core-radius. By using the finite horizon fractional gradient introduced by Bellido, Cueto, and Mora-Corral, we consider a nonlocal model of semi-discrete dislocations, in which the stored elastic energy is computed via the fractional gradient of order $1 - \alpha$. As α goes to 0, we show that suitably rescaled energies Γ -converge to the macroscopic strain-gradient model of Garroni, Leoni, and Ponsiglione. This is a joint work with Stefano Almi (University of Naples Federico II), Manuel Friedrich (Johannes Kepler University Linz), and Francesco Solombrino (University of Salento).

Variational phase-field models of cohesive fracture

Schedule: July 8 17:30-18:00 Room 445

Sergio Conti

University of Bonn, Germany

Abstract:

Cohesive-zone models are free-discontinuity problems with a surface energy that converges to zero for small values of the jump, and to a positive, finite value for large values of the jump. Their approximation with a phase-field model requires an interaction between the damage variable and the strain that depends on the regularization parameter. I will discuss recent progress on the development of these approximations and on the study of the limiting model. The talk is based on joint work with Flaviana Iurlano and Matteo Focardi.

Phase-field approximation of sharp-interface energies accounting for lattice symmetry

Schedule: July 7 17:30-18:00 Room 445

Vito Crismale

Sapienza Università di Roma, Italy

Abstract:

The talk concerns a phase field approximation for sharp interface energies, defined on partitions, as appropriate for modeling grain boundaries in polycrystals. The label takes value in $O(d)/G$, where G is the point group of a lattice. The limiting surface energy behaves for small angles as $|s| \log |s|$, according to the Read and Shockley law. These functionals can be used for image reconstruction of grain boundaries. Joint work with S. Conti (HCM Bonn), A. Garroni, A. Malusa (Sapienza).

Gamma-convergence of the square sticky disk to the octagonal crystalline perimeter

Schedule: July 7 17:00-17:30 Room 445

Giacomo Del Nin

Max Planck Institute Leipzig, Germany

Abstract:

We consider a variant of the sticky disk model for N interacting particles in the plane, where distances are evaluated by means of the supremum norm instead of the Euclidean norm. We show crystallization for minima of such an energy (for fixed N) and we prove Gamma-convergence (in the limit as N goes to infinity) of suitably rescaled energies to the anisotropic perimeter with octagonal Wulff shape. The key result to establish this is an energy decomposition for graphs in the plane that hinges upon the notion of angular defect, and that is potentially adaptable to other energies. The talk is based on joint work with Lucia De Luca (IAC-CNR).

Homogenisation of free discontinuity problems with cohesive type surface terms

Schedule: July 8 16:30-17:00 Room 445

Davide Donati

SISSA, Trieste, Italy

Co-Author(s): Gianni Dal Maso

Abstract:

We study homogenisation problems for free discontinuity functionals depending on vector-valued functions under new hypotheses on the surface energies. We prove necessary and sufficient conditions for an homogenisation phenomenon to occur and show that these conditions are always satisfied under the usual hypotheses of stochastic homogenisation.

Quasi-static crack growth in cohesive-type fracture

Schedule: July 8 8:00-8:30 Room 445

Manuel Friedrich

JKU Linz, Austria

Abstract:

In this talk, I present an existence result for a variational model of quasi-static crack growth for a class of cohesive fracture energies with an activation threshold. The evolution is characterized by an irreversibility condition in terms of a maximal opening variable, a global stability, and an energy balance.

Variational problems with nonlocal gradients: Heterogeneous horizons and local boundary conditions

Schedule: July 7 8:00-8:30 Room 445

Carolin Kreisbeck

KU Eichstätt-Ingolstadt, Germany

Co-Author(s): Hidde Schönbberger

Abstract:

Motivated by peridynamic models capturing discontinuities and singularities in material behavior, and building on recent advances in nonlocal hyperelasticity, this talk studies a class of variational problems involving integral functionals with nonlocal gradients. Specific to our set-up is a space-dependent interaction range that vanishes at the boundary of the reference domain. This ensures that the operator depends only on values within the domain and localizes to the classical gradient at the boundary, which allows for a seamless integration of nonlocal modeling with local boundary values. We will discuss properties of the associated Sobolev spaces, focusing in particular on the analysis of a trace operator and the proof of a Poincaré inequality. A central ingredient of our approach is to exploit connections with pseudo-differential operator theory. As an application, we show the existence of minimizers for functionals with quasiconvex or polyconvex integrands depending on heterogeneous nonlocal gradients, subject to local Dirichlet-, Neumann- or mixed-type boundary conditions.

On quantitative properties of Griffith quasi-minimizers

Schedule: July 8 9:30-10:00 Room 445

Camille Labourie

University of Lorraine, France

Co-Author(s): Antoine Lemenant, Lorenzo Lamberti, Yana Teplitskaya

Abstract:

Griffith quasiminimizers (in the sense of David and Semmes) are meant to represent minimizers of Griffith-type energies with possibly highly irregular coefficients. I will present recent regularity results such as uniform rectifiability, existence of espace curves, finiteness of traces and explain why no stronger regularity property can hold for all such quasiminimizers.

A variational approach to topological singularities through Mumford-Shah type functionals

Schedule: July 7 15:30-16:00 Room 445

Lucia De Luca

IAC-CNR Roma, Italy

Abstract:

We will present variational approaches to the analysis of topological singularities in the plane, starting from the - nowadays - classical Ginzburg-Landau (GL) model and core-radius (CR) approach. We will introduce a third approach inspired by the Mumford-Shah functional used in the context of image segmentation. Within our framework, the order parameter is an *SBV* map taking values in the unit sphere of the plane; the bulk energy is the squared L^2 norm of the approximate gradient whereas the penalization term is given by the length of the jump set, scaled by a small parameter. After providing a notion of Jacobian determinant for *SBV* maps, we show that at any logarithmic scale our functional is "variationally equivalent" to the "standard" (CR) and (GL) models. Joint work with Vito Crismale, Nicolas Van Goethem and Riccardo Scala.

Lower energy scaling bounds of singular perturbation models for higher order laminates via Fourier-based localization methods

Schedule: July 7 9:00-9:30 Room 445

Lennart Machill

Rheinische Friedrich-Wilhelms-Universität Bonn, Germany

Co-Author(s): Angkana Rüland, Antonio Tribuzio, Timo Hofmann

Abstract:

Fourier-based localization methods can be used to obtain lower scaling bounds for singular perturbation models. To illustrate this approach, we begin with a three-well problem within the theory of geometrically linearized elasticity. We then consider settings with more wells and discuss the singular perturbed Tartar square, revisiting the results by Rüland and Tribuzio (2022). We also briefly compare the technique with the results by Chan and Conti (2015), which rely on real-space localization methods, and discuss the extent to which the Fourier-based approach can be applied in the geometrically nonlinear case. The talk is based on joint works with Angkana Rüland, Antonio Tribuzio, and Timo Hofmann.

Gamma-convergence for the plane-to-wrinkles transition problem

Schedule: July 8 15:00-15:30 Room 445

Roberta Marziani

University of Siena, Italy

Co-Author(s): Peter Bella

Abstract:

Motivated by physical experiments, we consider a variational problem modeling transition between flat and wrinkled region in a thin elastic sheet. We start with a description of the model and of some related results due to Bella and Kohn. We then perform an asymptotic analysis, via Γ -convergence, as the sheet thickness goes to zero. The limiting problem is scalar and convex, but constrained and posed for measures. We complement the analysis by proving existence of a minimizer for the limiting functional as well as equipartition of the energy.

Tuning chirality and the emergence of antiskyrmions

Schedule: July 7 14:30-15:00 Room 445

Christof Melcher

RWTH Aachen University, Germany

Abstract:

We investigate the role of anisotropic chirality in chiral field theories and its impact on the stabilization and emergence of antiskyrmions. Extending classical models of chiral magnetism, we incorporate direction-dependent Dzyaloshinskii-Moriya interactions to capture anisotropic symmetry breaking. This framework reveals that anisotropy fundamentally alters the topological energy landscape, enabling the formation of antiskyrmionic textures alongside conventional skyrmions. We analyze the conditions under which antiskyrmions are energetically favorable, emphasizing the interplay between crystalline symmetry, chirality, and external fields. Our results provide a unified theoretical perspective consistent with recent experimental observations and prior work on micromagnetic energy minimization, highlighting anisotropic chirality as a key mechanism for engineering topological spin structures in magnetic materials.

Analysis of a Nonlocal Variational Model for Pattern Formation in Biomembranes

Schedule: July 7 8:30-9:00 Room 445

Anastasija Pesic

WIAS Berlin, Germany

Co-Author(s): Sara Daneri, Eris Runa

Abstract:

In this talk, we present a variational model motivated by lipid raft formation in cellular membranes. The energy combines a short-range attractive interaction, modeled by a Modica--Mortola term, with a long-range repulsive interaction given by a Yukawa kernel. We study minimizers of this functional in a certain parameter regime, in which the competition between these two effects leads to pattern formation. We will present a new Γ -convergence result. This talk is based on a joint work with Sara Daneri and Eris Runa.

A notion of s-fractional mass for 1-currents in higher codimension

Schedule: July 7 13:30-14:00 Room 445

Marcello Ponsiglione

Sapienza, University of Roma, Italy

Abstract:

We will introduce and discuss a notion of s-fractional mass for 1-currents, generalizing the s-fractional perimeter in the plane to higher codimension singularities. We will present basic compactness and density properties for such a notion, and discuss possible future directions of investigation

From discrete to continuum in the helical XY-model: emergence of chirality transitions.

Schedule: July 7 14:00-14:30 Room 445

Francesco SOLOMBRINO

Università del Salento, Italy

Co-Author(s): Marco Cicalese, Dario Reggiani, and Matthias Ruf

Abstract:

We study the energy per particle of a ferromagnetic-anti-ferromagnetic frustrated spin chain with nearest and next-to-nearest interactions close to the Landau-Lifschitz point (where the helimagnetic-ferromagnetic transition occurs), as the number of particles diverges. We rigorously prove the emergence of chiral ground states and we compute, by performing the Γ -limits of proper renormalizations and scalings, the energy for a chirality transition, if spins take value in the unit sphere S^1 . Such a result does not hold if spins are S^2 valued, as in this case, as it is well established that in this case chirality transitions may emerge with vanishing energy. Inspired by recent work on the N-clock model, we consider a spin model where spins are constrained to a diverging number k_n of copies of S^1 covering S^2 . We identify a critical energy-scaling regime and a threshold for the divergence rate of k_n , below which the Γ -limit of the discrete energies capture chirality transitions while retaining an S^2 -valued energy description in the continuum limit.

Energy of semi-coherent interfaces

Schedule: July 7 16:30-17:00 Room 445

Emanuele Spadaro

University of Rome La Sapienza, Italy

Co-Author(s): Valerio Corica

Abstract:

In this talk I will discuss a variational model for the energy of inter-crystalline boundaries that arise from differences in atomic spacing. The functional is a variant of the well-known Lauteri-Luckhaus energy for the proof of the Read-Shockley formula for tilt grain boundaries. In the case of semi-coherent interfaces (i.e., with small misfit between the crystal lattices), we show that the interfacial energy scales super-linearly with the misfit parameter, thus justifying in a more general setting the results of van der Merwe.

Linearization of Quasistatic Fracture Evolution in Brittle Materials

Schedule: July 8 8:30-9:00 Room 445

Pascal Steinke

Institute for Applied Mathematics, University of Bonn, Germany

Co-Author(s): S. Conti, M. Friedrich, K. Stinson

Abstract:

In this talk, we discuss a linearization result for quasistatic fracture evolution in nonlinear elasticity. As the stiffness of the material tends to infinity, we show that rescaled displacement fields and their associated crack sets converge to a solution of quasistatic crack growth in linear elasticity without any a priori assumptions on the geometry of the crack set. This result corresponds to the evolutionary counterpart of the static linearization result by M. Friedrich, where a Griffith model for nonsimple brittle materials has been considered featuring an elastic energy which also depends suitably on the second gradient of the deformations. The proof relies on a careful study of unilateral global minimality, as determined by the nonlinear evolutionary problem, and its linearization together with a variant of the jump transfer lemma in GSBD proven by M. Friedrich and F. Solombrino. This is a joint project with M. Friedrich (Linz, Austria) and K. Stinson (Salt Lake City, Utah).

Concentration-Compactness in Fracture Mechanics

Schedule: July 8 9:00-9:30 Room 445

Kerrek Stinson

University of Utah, USA

Co-Author(s): W. M. Feldman

Abstract:

Motivated by variational models for fracture, we discuss a new proof of compactness for $GSBV^p$ functions without a priori bounds on the function itself. Our proof is based on the classical idea of concentration-compactness, making it quite intuitive. Further, so far as we are aware, this is the first time the connection to concentration-compactness has been made explicit for problems in fracture mechanics.

Multiscale analysis and homogenization of nonlocal thin films

Schedule: July 7 9:30-10:00 Room 445

Antonio Tribuzio

University of Bonn, Germany

Abstract:

In this talk, we will introduce a nonlocal, variational model for thin films. We consider family of functionals of convolution-type defined on a thin domain of thickness γ with the size of the most effective interactions between points being of order ε . After discussing the correct rescaling, we study the Γ -convergence of these energies as both parameters go to zero to a local integral functional defined on a lower dimensional domain. In the case of periodic homogenization, we can show that a separation of scales takes place. This is a work in collaboration with Nadia Ansini.

Measure-valued solutions for non-associative finite plasticity

Schedule: July 8 15:30-16:00 Room 445

Andreas Vikelis

University of Vienna, Austria

Co-Author(s): Ulisse Stefanelli

Abstract:

The variational treatment of evolutionary nonassociative elasto-plasticity at finite strains remains unexplored. In this direction, following the concept of energetic solutions, we present an existence result for measure-valued solutions of the quasistatic evolution problem which are stable and balance the energy. In particular, we apply a modification of the standard time-discretization scheme, considering Young measures generated by piecewise constant interpolants of time-discrete solutions of a properly defined minimization problem. A key point in our analysis is the limit passage in the dissipation. The latter calls for time-continuity properties of the stresses which are not expected in the quasistatic framework. To overcome this obstacle we introduce a regularization of the generalized stress in the definition of our energetic solutions.

Dimension reduction in dynamical continuum mechanics

Schedule: July 8 14:30-15:00 Room 445

Riccardo Voso

UTIA, Czech Academy of Sciences, Czech Rep

Co-Author(s): Martin Kruzik

Abstract:

In this talk, we discuss the derivation of a membrane model for hyper viscoelastic materials with inertia, starting from the full three-dimensional theory. At first, the hyperbolic minimizing movements scheme is introduced. This is a two time scale variational approximation which accounts for the reformulation of the problem in terms of incremental minimization of a energy-dissipation functional, where inertia is discretized in time. Within this framework, the asymptotic analysis as the thickness of the body vanishes is carried out via a Γ convergence argument at the level of the functional and, subsequently, the continuous in time dynamics is recovered.

The random fractional obstacle problem

Schedule: July 8 13:30-14:00 Room 445

Caterina Ida Zeppieri

University of Muenster, Germany

Co-Author(s): Francesco Deangelis, Matteo Focardi

Abstract:

Nonlocal energies, such as fractional Sobolev seminorms, arise naturally in mathematical models involving long-range interactions. In this talk, we study minimizers of such energies that vanish on a collection of small balls with random centers and radii, leading to a bilateral (fractional) obstacle problem. We will present a homogenization result that holds under minimal assumptions on the distribution and size of the obstacles, which are generated by a stationary marked point process. In particular, the obstacles may overlap and form clusters with positive probability, giving rise to a complex microstructure. Our analysis identifies the limiting energy and shows how it reflects the underlying probability distribution of the obstacles.

Special Session 127 : Nonlocal models arising in biology and ecology

Organizer(s): Nikos Kavallaris , Marvin Fritz , Runzhang Xu

Introduction: This mini-symposium focuses on recent advances in the analysis and numerical treatment of nonlocal models emerging in biology and ecology. Such models, which often incorporate long-range interactions, spatial heterogeneity, or memory effects, provide powerful tools for capturing complex biological phenomena, including population dispersal, collective behavior, disease dynamics, and pattern formation. The symposium will highlight theoretical developments in the well-posedness, stability, and asymptotic behavior of nonlocal partial differential equations, as well as the design and implementation of efficient computational methods. Contributions will span a broad spectrum of applications and mathematical approaches, fostering interdisciplinary dialogue between analysis, computation, and biological modeling.

Elliptic relaxation of a degenerate Cahn-Hilliard tumour growth model

Schedule: July 9 15:00-15:30 Room 425

Matteo Fornoni

Università degli Studi di Milano, Italy

Co-Author(s): Cecilia Cavaterra, Maurizio Grasselli, Benoit Perthame

Abstract:

We consider a phase-field system modelling solid tumour growth. This system consists of a Cahn-Hilliard equation coupled with a nutrient equation. The former is characterised by a degenerate mobility and a singular potential of a single-well type, promoting short-range attraction and long-range repulsion for better biological consistency. Both equations are subject to suitable reaction terms which model proliferation and nutrient consumption. Chemotactic effects are also taken into account. Adding an elliptic regularisation, depending on a suitable relaxation parameter, in the equation for the chemical potential, we prove the existence of a weak solution to an initial and boundary value problem for the relaxed system. Then, we let the relaxation parameter go to zero, and we recover the existence of a weak solution to the original system.

Asymptotic models for tumor growth

Schedule: July 9 9:00-9:30 Room 425

Rafael Granero Belinchon

Universidad de Cantabria, Spain

Co-Author(s): Martina Magliocca

Abstract:

In this talk we will present two new models of tumor growth. These models take the form of nonlinear and nonlocal evolutionary PDE and they allow for arbitrary multilayer geometries. Furthermore, we will present the well-posedness theory associated to these equations.

Nonlocal-to-Local Convergence for a Diffuse Interface Model for Two Phase Flow with Matched Densities

Schedule: July 9 9:30-10:00 Room 425

Christoph Hurm

University of Regensburg, Germany

Co-Author(s): Patrik Knopf, Andrea Poiatti

Abstract:

We prove convergence of a sequence of strong solutions to a diffuse interface model for the two-phase flow of incompressible fluids with matched densities with a nonlocal Cahn-Hilliard equation to the strong solution to the corresponding system with a standard local Cahn-Hilliard equation. The analysis is done in the case of constant viscosity. The proof is based on an energy method and convergence of the linearized operators in the Cahn-Hilliard equations.

Traveling wave-like solutions to a time-fractional Fisher-KPP type equation

Schedule: July 9 14:00-14:30 Room 425

Hiroshi Ishii

Hokkaido University, Japan

Abstract:

In this talk, we study a time-fractional Fisher-KPP type equation in which the time derivative is given by the Caputo derivative. The main focus is on the long-time behavior of front solutions. After briefly reviewing the background of the equation, we present numerical results and discuss the qualitative properties of the solutions. It is known that this equation does not admit classical traveling wave solutions. To describe the long-time behavior, we assume that the solution asymptotically behaves like a traveling wave solution and analyze possible wave profiles to which the solution may converge. Based on this analysis, we construct traveling wave-like solutions that describe the asymptotic behavior of the front solution.

Traveling waves in a virus infection model of cell-to-cell transition

Schedule: July 9 13:30-14:00 Room 425

Yoshihisa Morita

Ryukoku University, Japan

Abstract:

Some in vitro experiments have observed the propagation of viral infection through cell-to-cell contact. Motivated by this phenomenon, we consider a cell-to-cell infection model consisting of variables representing the concentrations of target cells, eclipse-phase cells, infectious cells, and dead cells. The model describes the spread of infection through spatially discrete coupling between neighboring infectious and target cells. Numerical simulations demonstrate the emergence of traveling waves representing the propagation of the infectious state. We establish the existence of such traveling waves by reformulating the system as a nonlinear integral equation and applying a fixed-point argument. We also show that an integro-differential formulation of the model admits traveling wave solutions. This talk is based on the work of Asai-Iwami-Morita (2026).

Well-posedness for damped hyperbolic equation with critical Hartree type nonlinearity

Schedule: July 9 14:30-15:00 Room 425

Chao Yang

AGH University of Krakow, Poland

Abstract:

In this talk, we are concerned with the well-posedness of the initial boundary value problem for a hyperbolic equation with strong damping, weak damping, and Hartree type nonlinearity with Hardy-Littlewood-Sobolev critical exponent. Local existence of the solution is established via the Galerkin method and the Banach fixed point theorem. To address difficulties arising from the damping structure, the nonlocal characteristic of the Hartree type nonlinearity, and the lack of compactness caused by the critical exponent, we develop a suitable potential well framework and prove the invariance of associated manifolds. This framework allows us to obtain global existence and finite time blowup results at different initial energy levels. We further analyze the dynamical behavior of solutions, including asymptotic properties and blowup time estimates. Finally, we examine the continuous dependence of global solutions on initial data and coefficients of dampings.

Special Session 128 : New Trends in Mathematical Fluid Dynamics and Related Problems

Organizer(s): Elena Salguero , Martina Magliocca , Francisco Mengual

Introduction: This session is focused on the analysis of partial differential equations (PDEs) arising in fluid dynamics and related natural phenomena. This is a highly active area in mathematics, involving central problems such as the Navier–Stokes Millennium Problem. In recent years, there has been notable progress on key questions concerning the existence and uniqueness of solutions, long-time behavior, formation of singularities, and non uniqueness phenomena in various fluid models. The aim of this session is to bring together experts from different backgrounds to share their recent developments, encourage the exchange of ideas, and foster new collaborations.

Quantitative classification of potential Navier-Stokes singularities beyond the blow-up time

Schedule: July 6 17:30-18:00 Room 826

Tobias Barker

University of Bath, England

Abstract:

It remains an open problem whether or not solutions to the 3D Navier-Stokes equations with smooth data remain smooth for all time. All previously known regularity criteria are formulated in terms of a blow-up time (where the solution loses smoothness), which make it practically impossible to use such necessary conditions to test the viability of certain numerically computed candidates. Motivated by these issues, we give the first quantitative classification of potentially singular solutions at any given time in the region of potential blow-up times. The quantitative lower bounds prior to any potential blow-up time (and in the open vicinity of it) are in principle amenable to numerical testing.

Dynamics of oscillating water columns in the shallow water regime

Schedule: July 6 18:00-18:30 Room 826

Edoardo Bocchi

Politecnico di Milano, Italy

Abstract:

An oscillating water column is a wave energy converter in which waves enter a partially closed chamber, producing variations in the air volume inside, which, in turn, activate a turbine that generates electrical energy. In this talk, I will discuss the dynamics within such a configuration in the one-dimensional horizontal shallow water regime, modeled either by congested fluid models or by a spring-mass system inside the chamber interacting with the external waves.

Rotating solitons near monotone vortices

Schedule: July 6 18:30-19:00 Room 826

Angel Castro
ICMAT, Spain

Abstract:

In this talk we will consider the existence of rotating solutions arbitrarily close (in some topology) to radial monotone decreasing vorticity for 2D Euler. In a paper by Bedrossian, Coti-Zelati and Vicol was shown that radial monotone decreasing vorticities are stable at the linear level, thus, our result shows that this phenomenon can break even for small perturbation. The problem is related with the stability of shear flows and the existence of stationary and traveling waves solution near them. We also review some results on this topic. This is a joint work with Daniel Lear.

Non-uniqueness of solutions to the Navier-Stokes and related equations

Schedule: July 6 15:30-16:00 Room 826

Alexey Cheskidov
Westlake University, Peoples Rep of China

Abstract:

I will overview some recent results on non-uniqueness of solutions to the Navier-Stokes and related equations. I will describe a recent instantaneous blow-up construction, where for any smooth, divergence-free initial data, we construct a solution of the Navier-Stokes equations that exhibits Type I blow-up of the L^∞ norm, while remaining smooth. An instantaneous injection of energy from infinite wavenumber initiates a bifurcation from the classical solution, producing an infinite family of spatially smooth solutions with the same data and thereby violating uniqueness of the Cauchy problem. A key ingredient is the first known construction of a complete inverse energy cascade realized by a classical Navier-Stokes flow, which transfers energy from infinitely high to low frequencies. This is a joint work with Mimi Dai and Stan Palasek.

Instantaneous blowup for NSE

Schedule: July 7 15:00-15:30 Room 826

Mimi Dai
University of Illinois at Chicago, USA

Co-Author(s): Alexey Cheskidov, Stan Palasek

Abstract:

The quest of blowup solutions to the NSE remains a challenging topic. We will discuss a recent construction that illustrates a blowup phenomenon unexplored previously for the NSE. In particular, the constructed solutions start from smooth initial data and exhibit an instantaneous blowup saturating Type-I blowup rate at a finite time. Moreover, there are infinitely many such blowup solutions; and the non-uniqueness occurs in borderline spaces of known criteria which ensure uniqueness. This is joint work with Alexey Cheskidov and Stan Palasek.

Global well-posedness of a reduced model for micropolar fluids

Schedule: July 7 15:30-16:00 Room 826

Francesco Fanelli

Basque Center for Applied Mathematics, Spain

Abstract:

In this talk, we introduce a reduced model for micropolar fluids. By resorting to a suitable "good unknown" for the system, we show global persistence of regularity for smooth initial data, as well as global well-posedness for Yudovich-type initial data. This talk is based on joint works with Pedro Fernández-Dalgo (Basque Center for Applied Mathematics) and María Eugenia Martínez Martini (Universidad de Chile)

Turbulent Dynamos in Bounded Domains

Schedule: July 6 14:30-15:00 Room 826

Daniel Faraco

Universidad Autonoma de Madrid, Spain

Co-Author(s): Giacomo del Nin, Francisco Mengual and Sauli Lindberg

Abstract:

I will explain how an H principle obtained by simple convex integration scheme yields turbulent dynamos in arbitrary smooth bounded domains. The dynamo action happens simultaneously at various scales and can be made to be consistent with Taylor conjecture.

Desingularization of vortex sheets for the Euler equations

Schedule: July 7 14:00-14:30 Room 826

Antonio J. Fernández

Universidad Autónoma de Madrid, Spain

Abstract:

In this talk we show how to regularize vortex sheets by means of smooth, compactly supported vorticities that asymptotically evolve according to the Birkhoff-Rott vortex sheet dynamics. More precisely, consider a vortex sheet initial datum ω_{sing}^0 , which is a signed Radon measure supported on a co-dimension one manifold. We construct a family of initial vorticities $\omega_\varepsilon^0 \in C_c^\infty(\mathbb{R}^n)$, $n = 2, 3$, converging to ω_{sing}^0 distributionally as $\varepsilon \rightarrow 0^+$, and show that the corresponding solutions ω_ε to the incompressible Euler equations ($n = 2, 3$) converge to the measure defined by the Birkhoff-Rott system with initial datum ω_{sing}^0 . The talk is based on joint works with A. Enciso and D. Meyer.

Stable and unstable interface dynamics for gravity Stokes flow

Schedule: July 7 9:30-10:00 Room 826

Francisco Gancedo

Universidad de Sevilla, Spain

Abstract:

We study the evolution of the interface between two incompressible fluids with different densities in the Stokes regime under the effect of gravity. We analyze global-in-time regularity, stability, and instability results.

Leapfrogging motion for the Euler equations. Part 1.

Schedule: July 6 13:30-14:00 Room 826

Claudia Garcia

Universidad de Granada, Spain

Co-Author(s): Z. Hassainia, T. Hmidi

Abstract:

Leapfrogging motion describes a phenomenon in which two or more vortex rings, or other entities such as point vortices, repeatedly pass through each other. This occurs because the induced flow generated by one vortex ring causes it to accelerate and move through the other, after which the roles reverse. The resulting motion is a time-periodic solution in certain fluid models. Although this behavior has long been observed in experiments and numerical simulations, a rigorous mathematical construction has remained elusive. In this talk, we will first review some known results on leapfrogging motion for point vortices and vortex rings, and then present new analytical approaches to describe such phenomena.

Nonlinear stability of the three-dimensional Peskin problem

Schedule: July 6 17:00-17:30 Room 826

Eduardo Garcia-Juarez

Universidad de Sevilla, Spain

Co-Author(s): S.V. Haziot, P.-C. Kuo, Y. Mori, H. Zhou

Abstract:

The Peskin problem describes the motion of an elastic membrane immersed in an incompressible, viscous fluid, typically governed by the Stokes equations. The problem admits a contour dynamics formulation that leads to a nonlinear, nonlocal parabolic PDE. We study the well-posedness in critical spaces and the long-time behaviour of two-dimensional membranes in a three-dimensional fluid for initial interfaces with Lipschitz regularity, which is critical with respect to the natural scaling of the equation.

Leapfrogging motion for the Euler equations. Part 2

Schedule: July 6 14:00-14:30 Room 826

Zineb Hassainia

University of Granada, Spain

Co-Author(s): Claudia Garcia and Taoufik Hmidi

Abstract:

In this talk, we present a rigorous construction of time-periodic leapfrogging vortex rings for the three-dimensional incompressible Euler equations. More precisely, we prove the existence of solutions in which two coaxial vortex rings periodically exchange positions, as observed in experiments and numerical simulations. The construction relies on a desingularization of two interacting vortex filaments within the contour dynamics formulation, leading to a Hamiltonian description of nearly concentric vortex rings. A central difficulty arises from a singular small-divisor problem in the linearized dynamics, where the effective time scale degenerates with the ring thickness parameter. We overcome this issue by combining a degenerate KAM-type analysis with pseudo-differential techniques and a Nash-Moser iteration scheme. This approach yields families of nontrivial time-periodic solutions in an almost uniformly translating frame and thereby provides a rigorous mathematical construction of classical leapfrogging motion for axisymmetric Euler flows without swirl, with no restriction on the time interval of existence.

Pathological solutions of Navier-Stokes equations on $\mathbb{T}^2$ with gradients in Hardy spaces

Schedule: July 7 13:30-14:00 Room 826

Antonio Hidalgo Torne

Max Planck Institute for Mathematics in the Sciences, Spain

Co-Author(s): Jan Burczak

Abstract:

For an arbitrary smooth initial datum, we construct multiple nonzero solutions to the 2D Navier-Stokes equations, with their gradients in the Hardy space $\mathcal{H}^p$ with any $p \in (0, 1)$. Thus, in terms of the path space $C(\mathcal{H}^p)$ for vorticity, $p = 1$ is the threshold value distinguishing between non-uniqueness and uniqueness regimes. In order to obtain our result, we develop the needed theory of Hardy spaces on periodic domains.

Existence of the Sadovskii vortex patch

Schedule: July 7 8:30-9:00 Room 826

De Huang

Peking University, Peoples Rep of China

Co-Author(s): Jiajun Tong

Abstract:

The Sadovskii vortex patch--a steady contiguous anti-symmetric vortex-patch dipole solution of the 2D incompressible Euler equation--was numerically discovered over 50 years ago, whose was also observed as an accurate approximation of the large-time asymptotic profile in the head-on collision of two anti-symmetric vortex rings. In this talk, we present the first proof of existence of the Sadovskii vortex patch with 90-degree touching angles via a fixed-point approach. In particular, we show that the upper boundary of the Sadovskii vortex patch is given by a smooth even function that is monotonic on one side.

Global weak solutions and Hamiltonian conservation for the SQG equation

Schedule: July 6 15:00-15:30 Room 826

Jaemin Park

Yonsei University, Korea

Co-Author(s): Luigi De Rosa, Mickael Latocca

Abstract:

In this talk, I will discuss existence of weak solutions to the SQG equation with a rough initial data. We prove that when the initial data is has weak integrability, there exists a global weak solutions to the viscous SQG equation and the vanishing viscosity limit solves the inviscid SQG equation. We will also discuss Hamiltonian conservation of such weak solutions. The proof is based on an application of Lions' concentration compactness principle. This is a joint work with Luigi De Rosa (GSSI) and Mickael Latocca (Univ. Evry)

Small amplitude steady periodic water waves

Schedule: July 7 9:00-9:30 Room 826

Silvia Sastre Gómez

Universidad de Sevilla, Spain

Co-Author(s): David Henry

Abstract:

In this talk, we apply bifurcation theory to prove the existence of small amplitude steady periodic water waves, which propagate over a flat bed with a specified fixed mean-depth, and where the underlying flow has a discontinuous vorticity distribution.

Unstable vortices and sharp nonuniqueness for the forced SQG equation

Schedule: July 6 16:30-17:00 Room 826

Marcos Solera Diana

University of Valencia, Spain

Co-Author(s): A. Castro, D. Faraco and F. Mengual

Abstract:

We present a non-uniqueness result for the forced SQG equation in supercritical Sobolev spaces. A key step is the construction of smooth, compactly supported vortices that exhibit nonlinear instability. Moreover, we extend this approach to the forced 2D Navier-Stokes and dissipative SQG equations. This is joint work with A. Castro, D. Faraco and F. Mengual.

The Immersed Boundary Problem in 2-D: the Navier-Stokes Case

Schedule: July 7 8:00-8:30 Room 826

Jiajun Tong

Beijing International Center for Mathematical Research, Peking University, Peoples Rep of China

Co-Author(s): Jiajun Tong, Dongyi Wei

Abstract:

We will report recent progress on the 2-D immersed boundary problem with the Navier-Stokes equation, which models coupled motion of a 1-D closed elastic string and ambient fluid in the entire plane. This is based on joint works with Dongyi Wei.

Probabilistic solutions of the hydrodynamic equations

Schedule: July 7 14:30-15:00 Room 826

Francisco Torres de Lizaaur

Universidad de Sevilla, Spain

Abstract:

We will discuss ongoing work on probabilistic solutions of the equations of hydrodynamics. These are measures on the space of paths on velocity or vorticity fields that are supported on standard solutions.

Special Session 129 : Mathematics of Data Science and Applications

Organizer(s): Ding-xuan ZHOU , Xiang ZHOU

Introduction: Over the past a few decades, data science, machine learning, and deep learning, as the foundation of AI, have transformed the global economy and modern life. While much attention is focused on empirical success, there have been considerable mathematical structures and a growing body of mathematical theories about how these advances relate to observable properties of real-world systems. Discovering such structures may lead to important mathematical insights and implications for practitioners. This special session aims at interactions among approximation theory, harmonic analysis, machine learning, numerical analysis, dynamical system and statistics to foster further research in the fast-developing area of data science.

Graph Neural Networks: Principles and Applications

Schedule: July 9 8:00-8:30 Room 628

JIA CAI

Guangdong University of Finance & Economics, Peoples Rep of China

Co-Author(s): Jiahao Lai, Mengzhu Chen, Lin Gao, Ranhui Yan

Abstract:

In real-world scenarios, many data types are naturally represented as graphs with complex topological structures, inherently reflecting real-life systems. In recent years, Graph Neural Networks (GNNs) have attracted widespread attention as powerful tools for processing graph-structured data, with applications spanning diverse domains. This report examines several core issues in applying graph neural networks. First, we address stock movement prediction in the fintech domain. This task demands handling the complexity and dynamic nature of financial markets, making it a representative challenge in financial time series analysis. To tackle this issue, we propose a novel model: the Time-Lag and Edge Feature-Incorporated Graph Attention Network (TILE-GAT). Second, traffic flow prediction is a critical task in intelligent transportation systems, where the central challenge lies in capturing complex spatio-temporal dependencies within road networks. In particular, modeling spatial dependencies requires accurately and efficiently characterizing traffic flow transmission between nodes, especially the causal relationships among them. To address this limitation, we introduce a Spatio-Temporal Causal Graph Neural Network (STCGNN) framework for traffic flow prediction.

Decomposition of Electrodermal Activity Signals Using Matrix Separation

Schedule: July 9 8:30-9:00 Room 628

Xuemei Chen

University of North Carolina Wilmington, USA

Abstract:

We develop a new method for decomposing EDA signals using matrix decomposition. This matrix decomposition framework is new and we present some theoretical guarantees of recovery from a convex optimization problem. We further develop efficient algorithms for this convex optimization program where we also propose a preconditioning technique. Some numerical experiments with real data is also presented.

Stable Phase Retrieval for Gaussian Shift-invariant Signals

Schedule: July 9 16:30-17:00 Room 628

Cheng Cheng

Sun Yat-sen University, Peoples Rep of China

Abstract:

Gabor phase retrieval for signals has attracted considerable attention in recent years. For the more general short-time linear canonical transform (STLCT), which arises naturally in optical systems and canonical time--frequency analysis, existing work has so far focused mainly on uniqueness and sampling conditions. Explicit reconstruction formulas, quantitative stability estimates, and robust reconstruction algorithms, however, are still missing. In this paper, we study uniqueness, stability, and robust reconstruction for phase retrieval from phaseless STLCT measurements in the complex Gaussian shift-invariant space $V_{\beta}^{\infty}(\varphi)$.

Toward Theoretical Insights into Diffusion Trajectory Distillation via Operator Merging

Schedule: July 9 9:00-9:30 Room 628

Weiguo Gao

Fudan University, Peoples Rep of China

Co-Author(s): Ming LI

Abstract:

Diffusion trajectory distillation accelerates sampling by training a student model to approximate the multi-step denoising trajectories of a pretrained teacher model using far fewer steps. Despite strong empirical results, the trade-off between distillation strategy and generative quality remains poorly understood. We provide a theoretical characterization by reinterpreting trajectory distillation as an operator merging problem, differentiating our analysis between two distinct regimes. In the linear Gaussian regime, where approximation error is zero, we isolate optimization error, specifically signal shrinkage driven by finite training time, as the primary bottleneck. This characterization allows us to derive the theoretically optimal merging strategy, which exhibits a variance-driven phase transition and is computable via a Pareto dynamic programming algorithm. In the nonlinear Gaussian mixture regime, we prove that distilling composite steps incurs unavoidable approximation error due to the exponential growth of mixture components, and we quantify how these errors amplify across merges. Together, these results clarify the distinct theoretical mechanisms governing each regime and provide principled guidance for method selection. This is joint work with Ming Li.

Unbounded Density Ratio Estimation and Its Application to Covariate Shift Adaptation

Schedule: July 9 15:30-16:00 Room 628

Zhengchu Guo

Zhejiang University, Peoples Rep of China

Co-Author(s): Ren-Rui Liu, Jun Fan, Lei Shi

Abstract:

This talk addresses unbounded density ratio estimation--an underexplored yet critical challenge in statistical learning--and its application to covariate shift adaptation. We propose a three-step procedure utilizing unlabeled data from both source and target distributions: (1) estimating a relative density ratio; (2) truncating to control unboundedness; and (3) transforming the estimate back to the standard density ratio, which is then used as importance weights for regression. We establish non-asymptotic convergence guarantees for both the density ratio estimator and the resulting regression estimator, showing that under mild conditions, both achieve optimal or near-optimal rates. This work provides new theoretical insights into density ratio estimation and learning under covariate shift, extending classical theory to more practical settings.

Convergence of zeroth-order optimization with stochastic mirror descent

Schedule: July 9 13:30-14:00 Room 628

Ting HU

Xi'an Jiaotong University, Peoples Rep of China

Abstract:

We study a randomized zeroth-order algorithm that uses only differences of function values and integrates mirror descent for stochastic optimization. In convex problems, we present a new convergence analysis under γ -Hölder gradient continuity ($0 < \gamma \leq 1$) without boundedness assumptions, showing that the last iterate achieves rates of

$$\mathcal{O}\left(T^{-\frac{1}{2}}(\log T)^2\right),$$

matching optimal rates up to a logarithmic factor. In strongly convex settings, we analyze convergence in Bregman distance, establishing necessary and sufficient conditions for stochastic problems and linear rates for deterministic ones. For nonconvex problems, we derive convergence using the Bregman Forward-Backward envelope, a stronger stationary measure. Under the proximal Polyak-Lojasiewicz condition, we obtain fast convergence rates.

Separation of Non-Stationary Multi-Component Signals: Enhanced SST/Chirplet Methods and Their Engineering & Data Science Applications

Schedule: July 9 9:30-10:00 Room 628

Qingtang Jiang

Zhejiang Normal University, Peoples Rep of China

Abstract:

Real-world signals, such as those from mechanical systems or medical data, are typically non-stationary and composed of multiple time-varying components. Traditional methods often struggle with mathematical rigor or lack the flexibility needed for dynamic environments. This talk presents advanced mathematical frameworks for the high-resolution analysis and recovery of these multi-component signals. First, we discuss the Adaptive Synchrosqueezing Transform (SST), which improves upon standard wavelet- and STFT-based SST by adaptively selecting time-varying parameters to resolve blurry time-frequency representations. Second, we address the challenge of signals with crossover instantaneous frequencies—a scenario where traditional well-separated conditions fail. We introduce a Chirplet Transform-based approach and a mathematically rigorous Signal Separation Operator that acts as an overpass in the time-frequency plane to resolve intersecting components. Finally, we present robust performance of these methods across machinery fault diagnosis, social media depression screening, and radar signal classification; these advancements further form a rigorous, adaptive framework for non-stationary signal separation, whose integration with deep learning delivers high performance across these key engineering and data science domains.

Resolution Invariant Operator Learning via Encoder Decoder Representations: Limiting Kernels and Convergence Analysis

Schedule: July 9 14:30-15:00 Room 628

Lei Shi

Fudan University, Peoples Rep of China

Co-Author(s): Jiaqi Yang and Dingxuan Zhou

Abstract:

Operator learning aims to approximate mappings between infinite dimensional function spaces, while practical implementations rely on finite dimensional encoder decoder representations that often induce resolution dependent hypothesis classes and obscure the underlying operator being learned. We overcome this ambiguity by using a kernel based framework that identifies a resolution independent class of limiting operators associated with encoder decoder architectures. Starting from matrix valued kernel learning at a fixed finite resolution, we show that the encoder decoder structure admits an isometric lifting to an operator valued kernel formulation on function spaces. As input and output resolutions increase, encoder induced kernels converge to a resolution independent limiting kernel that characterizes the intrinsic operator class. Building on this limiting kernel perspective, we analyze stochastic gradient descent (SGD) for operator learning in encoder decoder settings. The framework applies to broad classes of kernels and encoder decoder constructions, including radial and dot product kernels; spectral truncation based encoders such as Fourier, polynomial, and wavelet based encoders; empirical principal component encoders; and kernel interpolation based encoding schemes. This is a joint work with Jiaqi Yang and Prof. Dingxuan Zhou.

Kolmogorov Superposition Theorem: Construction, Approximation and Networks

Schedule: July 9 15:00-15:30 Room 628

Li-Lian Wang

Division of Mathematical Sciences, Singapore

Abstract:

The Kolmogorov Superposition Theorem (KST, 1957), offers a mathematically elegant framework for expressing any high-dimensional continuous function as a superposition of one-dimensional continuous functions. This foundational result has recently gained renewed interest, particularly in neural networks. However, a major challenge remains: the one-dimensional functions resulted from all constructions are highly non-smooth. In this talk, we present a novel approximate version of KST involving C^2 inner functions and piecewise C^2 outer functions and show its applications in neural network approximations.

Convolution smoothed outcome weighted learning

Schedule: July 9 14:00-14:30 Room 628

Daohong Xiang

Zhejiang Normal University, Peoples Rep of China

Co-Author(s): Aoli Yang, Jun Fan

Abstract:

Precision medicine seeks to provide personalized healthcare by tailoring treatments to individual patient characteristics, making the development of individualized treatment rules (ITR) a central task. Outcome weighted learning serves as a powerful framework for estimating optimal , often relying on the hinge loss function due to its favorable statistical properties. However, the non-smooth nature of the hinge loss function can lead to computational difficulties, particularly in high-dimensional or small-sample settings. In this talk, we introduce and investigate a family of outcome weighted learning algorithms generated by convolution-type smoothed hinge loss functions and varying Gaussian kernels. We derive fast convergence rates for the excess value function of these proposed learning algorithms across different model selection strategies, showing that these rates are optimal under mild noise and margin conditions, up to logarithmic factors. Numerical simulations support our theoretical findings and indicate that the convolution smoothed hinge loss functions outperform the standard hinge loss function in terms of both computational efficiency and treatment value.

Special Session 130 : Data driven approaches for complex physical systems

Organizer(s): Li Wang , Rongjie Lai

Introduction: The growing availability of large-scale datasets is reshaping the landscape of physical modeling. While fundamental physical laws continue to underpin our understanding of physical systems, data offers new opportunities—enabling the replacement of empirical constitutive relations with learned models, or development of surrogate models for efficient inference. These advances highlight two key areas where deep learning has made significant strides: model prediction and operator learning. This special session aims to bring together leading researchers and practitioners to share insights and advance the frontiers of how deep learning can transform the classical field of applied and computational mathematics. By fostering collaboration and dialogue, we hope to accelerate progress in the development of data-driven approaches for modeling complex physical systems.

Proximal Optimal Transport Divergences and Stable Gradient Flows

Schedule: July 7 8:00-8:30 Room 427

Markos Katsoulakis

UMass Amherst, USA

Abstract:

We introduce proximal optimal transport divergences that provide a unifying variational framework interpolating between classical f-divergences and Wasserstein metrics. From a gradient-flow perspective, these divergences generate stable and robust dynamics in probability space, enabling the learning of distributions with singular structure, including strange attractors, extreme events, and low-dimensional manifolds, with provable guarantees in sample size. We illustrate how this mathematical structure leads naturally to generative particle flows for reconstructing nonlinear cellular dynamics from snapshot single-cell RNA sequencing data, including real patient datasets, highlighting the role of proximal regularization in stabilizing learning and inference in high dimensions.

Structure-Preserving Construction of Collision Operators for Kinetic Equations from Molecular Dynamics

Schedule: July 7 8:30-9:00 Room 427

Huan Lei

Michigan State University, USA

Abstract:

We introduce a data-driven approach to learn generalized collision operators from molecular dynamics. Unlike conventional models (e.g., Landau), the present operator takes a symmetry-breaking non-stationary form that depends not only on the relative velocity but also on the average velocity of the collision pair, capturing heterogeneous energy transfer arising from collective interactions with the environment. The constructed model strictly preserves the frame-indifference, conservation laws, and physical constraints such as the H-theorem. To enable efficient numerical evaluation, we develop a fast spectral separation method that represents the kernel as a low-rank tensor product of univariate basis functions. This formulation admits an $O(N \log N)$ algorithm and structure-preserving discretization. Numerical results demonstrate that the proposed model accurately captures plasma dynamics in the moderately coupled regime beyond the standard Landau model while maintaining high computational efficiency and structure-preserving properties.

Amortized approximation of probabilistic conditioning by neural operators

Schedule: July 7 9:00-9:30 Room 427

Nicholas H Nelsen

Cornell University, USA

Abstract:

Probabilistic conditioning concerns the identification of the distribution of a random variable X given a random variable Y . It is a cornerstone of science and engineering applications where modeling uncertainty is key. This problem has traditionally been addressed in machine learning by directly learning the conditional distribution of a fixed joint distribution. Instead, this talk solves the conditioning problem by identifying a single operator that maps any joint density to its conditional, thus amortizing over joint-conditional pairs. The talk establishes that density-to-density conditioning can be approximated to arbitrary accuracy by neural operators. The proof relies on new stability estimates for the conditioning operator over suitable classes of densities. Numerical experiments that train neural operators to condition a class of Gaussian mixtures illustrate the promise of the new framework.

Blood pressure monitoring with biophysics-informed machine learning models

Schedule: July 7 9:30-10:00 Room 427

Braxton Osting

Dept. Mathematics, University of Utah, USA

Abstract:

Measurement of blood pressure (BP) is essential for early diagnosis and management of hypertension, a condition that 45% of US adults have and a risk factor for development of heart failure, the leading cause of death in the US. Wearable technologies have the potential to transform BP monitoring by providing continuous assessments of cardiovascular health metrics and guiding clinical management. However, existing cuffless wearable devices for BP monitoring often rely on methods lacking theoretical foundations, such as pulse wave analysis or pulse arrival time, making them vulnerable to physiological and experimental confounders that undermine their accuracy and clinical utility. We developed a smartwatch device with real-time electrical bioimpedance (BioZ) sensing for cuffless hemodynamic monitoring. We elucidate the biophysical relationship between BioZ and BP via a multiscale analytical and computational modeling framework, and identify physiological, anatomical, and experimental parameters that influence the pulsatile BioZ signal at the wrist. A signal-tagged physics-informed neural network incorporating fluid dynamics principles enables calibration-free estimation of BP and radial and axial blood velocity. We successfully tested our approach with healthy individuals at rest and after physical activity including physical and autonomic challenges, and with patients with hypertension and cardiovascular disease in outpatient and intensive care settings. Our findings demonstrate the feasibility of BioZ technology for cuffless BP and blood velocity monitoring, addressing critical limitations of existing cuffless technologies.

Special Session 133 : New developments on nonlinear expectations

Organizer(s): Shige Peng , Juan Li

Introduction: Motivated by uncertainty problems, risk measures and the super-hedging in finance, Shige Peng introduced a fully nonlinear expectation, called G-expectation, which effectively characterize the Knightian uncertainty of data. Under the G-expectation framework a new type of Brownian motion, the so-called G-Brownian motion, has been introduced and the stochastic calculus with respect to the G-Brownian motion has been developed. The G-expectation theory has been widely used to evaluate random outcomes with model ambiguity, not using a single probability measure, but using the supremum over a family of possibly mutually singular probability measures. The theory of nonlinear expectations has been developing very dynamically thanks to its many typical applications, so in economics, finance, information and computation science and many other domains. In our symposium we will study some new developments on nonlinear expectations.

When Reinforcement Learning Aligns with Estimate-Then-Plug-In? Insights from Continuous-Time Portfolio Selection

Schedule: July 8 8:30-9:00 Room 421

Min Dai

The Hong Kong Polytechnic University, Hong Kong

Co-Author(s): Min Dai, Yanwei Jia, Zhichao Lu

Abstract:

Traditional dynamic decision-making under uncertainty typically follows an estimate-then-plug-in approach: specifying a model, estimating its parameters from historical data, and solving the resulting stochastic control problem analytically or numerically. In contrast, modern reinforcement learning (RL) directly learns optimal policies from data without estimating model parameters. Continuous-time RL methods have recently gained traction in financial decision-making, but it remains unclear when RL outperforms the traditional approach and why. We investigate these questions through continuous-time portfolio optimization using a relaxed control framework. Without transaction costs, we derive an analytical solution and develop a model-free q-learning algorithm to learn optimal trading strategies. Our theoretical results show that given continuous stock price data, the RL-learned policy matches the estimate-then-plug-in solution. Incorporating transaction costs, we find this equivalence still holds. Numerical experiments with synthetic data confirm these findings across various models. However, empirical studies demonstrate that our RL method significantly outperforms the traditional approach in realistic settings, likely because real-world stock price dynamics exhibit complex features not fully captured by parametric models.

Boundary stabilization of 1D hyperbolic balance laws

Schedule: July 8 13:30-14:00 Room 421

Long Hu

Shandong University, Peoples Rep of China

Abstract:

One-dimensional hyperbolic balance laws arise in many physical models, such as traffic flow, shallow water waves, gas pipelines, and oil drilling. In this talk, we will focus on the stabilization of these systems by means of boundary feedback control. We will show how to design nonlocal feedback controllers to rapidly stabilize such systems (linear or quasilinear, autonomous or non-autonomous, with local or nonlocal source terms...). In particular, for the linear system, we will use two-step scheme to stabilize the system in optimal finite-time using either one-sided or two-sided control inputs.

Doubly Reflected Backward SDEs Driven by G-Brownian Motion with Quadratic Generator

Schedule: July 8 17:00-17:30 Room 421

Hanwu Li

Shandong University, Peoples Rep of China

Co-Author(s): Hanwu Li, Peng Luo and Mengbo Zhu

Abstract:

In this talk, we study the doubly reflected backward stochastic differential equations driven by G-Brownian motion (G-BSDEs for short) when the generator has quadratic growth in the z -component. Based on the theory of G-BMO martingale and G-Girsanov theorem, we establish the existence and uniqueness result when the upper obstacle is almost a generalized $G\text{-}\mathbb{I}t^{\wedge\{o\}}$'s process. Moreover, the solution can be approximated monotonically by the solutions to a family of penalized reflected G-BSDEs with a lower obstacle, which plays an important role to establish the relation between doubly reflected G-BSDEs and fully nonlinear partial differential equations with double obstacles.

Mean field portfolio games with major-minor agents and random horizon

Schedule: July 8 17:30-18:00 Room 421

Wenqiang Li

Shandong University, Peoples Rep of China

Abstract:

We study a type of mean field portfolio games with a major and N minor agents with private information, where the major agent is not allowed to trade on the market after a given unpredictable and external default time to the market. The investment horizon of each minor agent is divided into two intervals with and without the major in the market, leading naturally to two sequential optimization problems. Using the martingale optimality principle, a Nash equilibrium of the limiting problem ($N \rightarrow \infty$) is characterized by a type of coupled multi-dimensional mean-field FBSDEs with quadratic growth and random horizon, which is solvable under a weak interaction assumption of minor agents. The convergence of Nash equilibrium between the limiting problem and the original $(N+1)$ portfolio games is also verified. We study the well-posedness and the stability results of a extended BSDEs with quadratic growth and random horizon in the Appendix.

Generalized Divergence Measures and Weak Convergence for the Sets of Probability Measures

Schedule: July 8 14:30-15:00 Room 421

Xinpeng Li

Shandong University, Peoples Rep of China

Abstract:

In this talk, we extend the asymmetric Kullback-Leibler divergence and symmetric Jensen-Shannon divergence from two probability measures to the case of two sets of probability measures. We establish some fundamental properties of these generalized divergences, including a duality formula and a Pinsker-type inequality. Furthermore, convergence results are derived for both the generalized asymmetric and symmetric divergences, as well as for weak convergence under sublinear expectations.

Anticipated backward stochastic evolution equations and maximum principle for path-dependent systems in infinite dimensions

Schedule: July 8 16:30-17:00 Room 421

Guomin Liu

Nankai University, Peoples Rep of China

Co-Author(s): Meng Wang, Jian Song

Abstract:

In this paper, we study the Pontryagin's maximum principle for the stochastic recursive optimal control problem of a class of path-dependent stochastic evolution equations. In the control system, the state process depends on its past trajectory, the control is delayed via an integral with respect to a general finite measure, and the final cost relies on the delayed state. To obtain the maximum principle, we introduce a functional adjoint operator for the non-anticipative path derivative and establish the well-posedness of an anticipated backward stochastic evolution equation in the path-dependent form, which serves as the adjoint equation.

Quadratic forward backward stochastic differential equations driven by G-Brownian motion

Schedule: July 8 15:30-16:00 Room 421

Peng Luo

Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

We consider quadratic forward backward stochastic differential equations driven by G-Brownian motion. Based on the theory of G-BMO martingale and G-Girsanov theorem, we establish the existence and uniqueness of solution on small time duration. We further provide some extensions.

Nonlinear Expectation: A Robust Framework for Uncertainty in Finance and AI

Schedule: July 8 8:00-8:30 Room 421

Shige Peng

Shandong University, Peoples Rep of China

Abstract:

In this talk, we firstly address a fundamental challenge in mathematical finance and data-driven AI: how to measure and control risk under deep uncertainty, where a single probability distribution cannot be reliably determined from data. Then we introduce the theory of nonlinear expectations as a paradigm shift, presenting foundational limit laws-the nonlinear law of large numbers and the nonlinear central limit theorem-that characterize asymptotic behavior under model ambiguity. Building on this framework, a practical ϕ -max-mean algorithm is developed for robust statistics and nonlinear distribution computation when the true data-generating distribution is unknown. We also show that phenomena governed by nonlinear expectations are pervasive, offering profound insights into quantitative risk management and the construction of reliable AI systems. By bridging deep mathematical theory with wide-ranging practical applications, this framework provides a unified and robust approach to decision-making under uncertainty.

A control method for solving high-dimensional fully coupled FBSDEs via deep learning

Schedule: July 8 15:00-15:30 Room 421

Ying Peng

Shandong University, Peoples Rep of China

Co-Author(s): Shaolin Ji, Shige Peng, Xichuan Zhang

Abstract:

In this talk, we present a control method for solving a high-dimensional stochastic Hamiltonian system with boundary conditions, which is essentially a Forward Backward Stochastic Differential Equation (FBSDE in short). Different from existing methods, we first formulate a stochastic optimal control problem whose extended Hamiltonian system is exactly the system to be solved. Then two different algorithms to calculate the stochastic optimal control via deep neural networks are designed respectively. Comparing with the Deep FBSDE method, our proposed algorithms demonstrate more stable performance.

On Infinite-Time Mean Field Games and the Associated Elliptic Master Equations

Schedule: July 8 9:30-10:00 Room 421

Yongsheng Song

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

We study discounted infinite-time mean field games, for which a Nash equilibrium is constructed using the stochastic maximum principle and infinite-time McKean-Vlasov forward-backward stochastic differential equations. We then prove that, at the Nash equilibrium, the value function of the representative player provides a viscosity solution to the corresponding elliptic master equation. Furthermore, we establish the uniqueness of classical solutions to the elliptic master equation under displacement monotonicity and certain growth assumptions. This talk is based on a joint paper with Zeyu Yang.

Comparison theorems for multi-dimensional BSDEs with jumps and applications to stochastic LQ control

Schedule: July 8 9:00-9:30 Room 421

Zuoquan Xu

The Hong Kong Polytechnic University, Peoples Rep of China

Co-Author(s): Ying Hu; Xiaomin Shi; Zuo Quan Xu

Abstract:

In this paper, we, for the first time, establish two comparison theorems for multi-dimensional backward stochastic differential equations with jumps. Our approach is novel and completely different from the existing ones for one-dimensional case. Using these and other delicate tools, we then construct solutions to coupled two-dimensional stochastic Riccati equation with jumps in both standard and singular cases. In the end, these results are applied to solve a cone-constrained stochastic linear-quadratic control problem and a mean-variance portfolio selection problem with jumps. Different from no jump problems, the optimal (relative) state processes may change their signs, which is of course due to the presence of jumps. This is a joint work with Ying Hu (Univ Rennes) and Xiaomin Shi (Shandong University of Finance and Economics).

Large Language Models training under Sublinear Expectation

Schedule: July 8 14:00-14:30 Room 421

Shuzhen Yang

Shandong University, Peoples Rep of China

Abstract:

As the complexity of large language models (LLMs) continues to grow, the scale of training data expands exponentially, and the inherent uncertainty in data distribution has emerged as a nonnegligible critical challenge. We incorporate the sublinear expectation theory into LLMs to analyze uncertainties inherent in training data. Leveraging the ϕ -max mean algorithm, we propose a novel cross-entropy loss function (Lossmax mean) and the corresponding training strategy (SLE-Strategy). Using a decoder-only Transformer as the base model, we conduct five sets of controlled experiments with different parameter sizes, comparing the model using SLE-Strategy (SLE-model) with model using traditional strategy. Experimental results demonstrate that the SLE-model achieves a substantial improvement in training efficiency, reducing the per-epoch training time by 57.46%-86.34% while maintaining a controllable performance gap. This innovative approach effectively balances cost and model performance, offering a promising direction for optimizing LLM training in resource-constrained scenarios.

Special Session 134 : Mean field stochastic control problems and related topics

Organizer(s): Juan Li , Rainer Buckdahn

Introduction: Mean-field (or, McKean-Vlasov) SDEs have been studied for a long time and have found a lot of applications in different domains. Roughly speaking, in a more general sense, mean-field problems study strategic decision making by small interacting agents in very large populations, modeled by equations not only depending on the controlled state process and its control but also on their law. Recently, with their pioneering seminal papers (2006-2007) on mean-field games and their applications in economics, finance and game theory, Lasry and Lions have given with a ground-breaking novel approach new impulses to this research topic, opened the way to new applications and attracted many researchers to this topic. One of these applications is the study of mean-field stochastic optimal control problems and mean-field games. Our symposium will mainly be devoted to optimal control problems for mean-field forward-backward stochastic differential equations.

Path-depending controlled mean-field coupled forward-backward SDEs. The associated stochastic maximum principle

Schedule: July 9 8:00-8:30 Room 619

Rainer RB Buckdahn

Universite de Bretagne Occidentale, France

Co-Author(s): Juan Li, Junsong Li, Chuanzhi Xing

Abstract:

We present a new type of mean-field coupled forward-backward stochastic differential equations (MFFBSDEs). The novelty consists in the fact that the coefficients of both the forward and the backward SDEs depend not only on the controlled solution processes (X, Y, Z) at the current time t , but also on the law of the paths of (X, Y, u) of the solution process and the control process. The existence of the solution for such a MFFBSDE fully coupled through the law of the paths of (X, Y) in the coefficients of both the forward and the backward equations is proved under rather general assumptions. Concerning the law, we just suppose the continuity under the 2-Wasserstein distance of the coefficients with respect to the law of (X, Y) . The uniqueness is shown under Lipschitz assumptions and the non anticipativity of the law of X in the forward equation. The main part of the work is devoted to the study of the Pontryagin maximal principle for such a MFFBSDE. The dependence of the coefficients on the law of the paths of the solution processes and their control makes that a completely new and interesting criterion for the optimality of a stochastic control for the MFFBSDE is obtained. In particular, also the Hamiltonian is novel and quite different from that in the existing literature. Last but not least, under the assumption of convexity of the Hamiltonian we show that our optimality condition is not only necessary but also sufficient.

A stochastic porous media Schrodinger equation: Feynman-type motivation, well-posedness and control interpretation

Schedule: July 9 13:30-14:00 Room 619

Ioana Ciotir

INSA Rouen Normandie, France

Co-Author(s): Ioana Ciotir, Dan Goreac, Juan Li, Xinru Zhang

Abstract:

This paper's aim is threefold. First, using Feynman's path approach to the derivation of the classical Schrödinger equation in Feynman (Rev Mod Phys, 1948) and by introducing a slight path (or wave) dependency of the action, we derive a new class of equations of Schrödinger type where the driving operator is no longer the Laplace one but rather of complex porous media type. Second, using suitable concepts of monotonicity in the complex setting and on appropriate functional spaces, we show the existence and uniqueness of the solution to this type of equation. In the formulation of our equation, we adjoin possible measurement absolute errors translating in an additive Brownian perturbation and interactions between different waves translating in a mean-field (or McKean-Vlasov) dependency of drift coefficient. Finally, using Fitzpatrick's characterization of maximal monotone operators (Schrödinger Phys Rev, 1926) we propose a Brezis-Ekeland-type characterization of the solution of the deterministic equation via a control problem. This is envisaged as a possible way to overcome strict monotonicity requirements in the complex setting.

Continuity problems for Backward Stochastic Differential Equations with singular terminal condition.

Schedule: July 9 8:30-9:00 Room 619

Laurent Denis

Le Mans University, France

Abstract:

We study the continuity problem at the terminal time of the minimal supersolution of backward stochastic differential equation with singular terminal condition. In the continuous case, where the equation is driven by a Brownian motion we give a general criterion on the generator ensuring continuity up to terminal time. We also prove that the solution has a Malliavin derivative, which is the limit of the derivative of the approximating sequence and provide the asymptotic behavior of this derivative close to the terminal time. We apply this result to the regularity of the related partial differential equation by using the associated integro-partial differential equation. Finally, we prove that if there are jumps (i.e. the operator of the PDE is non local), we observe a propagation of the singularity, contrary to the continuous case (local operator). This talk is based on several joint works with D. Cacitti-Holland and A. Popier.

Cramer-Lundberg Models with Mean-Field Claims and Premia

Schedule: July 9 9:30-10:00 Room 619

Dan Goreac

Laval University, Canada

Co-Author(s): Hezhen Bao, Dan Goreac, Juan Li, and Radu Mitric

Abstract:

This talk introduces McKean-Vlasov stochastic differential equations to model insurance reserves in a large, interacting pool of insurers. Our framework departs from the classical Cramér-Lundberg model by letting premiums and claim distributions adapt to the evolving cross-sectional distribution of capital, thereby capturing feedback and contagion effects. Using characteristic-function based integral and recursive formulas together with iterative moment calculations, we track distributional dynamics over time and design adaptive premium and systemic risk measures. These methods yield distribution-sensitive adjustment coefficients and supermartingale bounds for ruin probabilities, updating classical ruin theory for modern interconnected insurance markets.

A global stochastic maximum principle for mean-field forward-backward stochastic control systems with quadratic generators

Schedule: July 9 9:00-9:30 Room 619

Juan Li

Shandong University, Peoples Rep of China

Co-Author(s): Rainer Buckdahn, Juan Li, Yanwei Li, Yi Wang

Abstract:

Our talk is devoted to the study of Peng's stochastic maximum principle (SMP) for a stochastic control problem composed of a controlled forward stochastic differential equation (SDE) as dynamics and a controlled backward SDE which defines the cost functional. Our studies combine the difficulties which come, on one hand, from the fact that the coefficients of both the SDE and the backward SDE are of mean-field type (i.e., they do not only depend on the control process and the solution processes but also on their law), and on the other hand, from the fact that the coefficient of the BSDE is of quadratic growth in Z . Our SMP is novel, it extends in a by far non trivial way existing results on SMP. The talk is based on a joint work with Rainer Buckdahn (UBO, France), Yanwei Li (SDU, China), Yi Wang (SDU, China).

Particle Approximation for Conditional Mean Field SDEs

Schedule: July 9 17:30-18:00 Room 619

Yunzhang Li

Fudan University, Peoples Rep of China

Abstract:

In this talk, we construct a type of interacting particle systems to approximate a class of stochastic differential equations whose coefficients depend on the conditional probability distributions of the processes given partial observations. After proving the well-posedness and regularity of the particle systems, we establish a quantitative convergence result for the empirical measures of the particle systems in the Wasserstein space, as the number of particles increases. Moreover, we discuss an Euler-Maruyama scheme of the particle system and validate its strong convergence. A numerical experiment is conducted to illustrate our results. This talk is based on the joint work with Kai Du and Yuyang Ye.

A Novel Approach to Peng's Maximum Principle for Mean Field SDE

Schedule: July 9 14:00-14:30 Room 619

Johan Benedikt Spille

Technical University Berlin, Germany

Co-Author(s): Johan Benedikt Spille, Wilhelm Stannat

Abstract:

We present a novel approach to the proof of Peng's maximum principle for McKean-Vlasov stochastic differential equations (SDE). The main step is the introduction of a third adjoint equation, a conditional McKean-Vlasov backward SDE, to accommodate the dualization of quadratic terms containing two independent copies of the first-order variational process. This is an intrinsic extension of the maximum principle from Peng for standard SDE and gives a conceptually consistent proof. Our approach will be useful in further extensions to the common noise setting and the infinite dimensional setting.

BSDEs and BSVIEs with anticipating generators

Schedule: July 9 16:30-17:00 Room 619

Hanxiao Wang

Shenzhen University, Peoples Rep of China

Co-Author(s): Jiongmin Yong, Chao Zhou

Abstract:

For a backward stochastic differential equation (BSDE, for short), when the generator is not progressively measurable, it might not admit adapted solutions, shown by an example. However, for backward stochastic Volterra integral equations (BSVIEs, for short), the generators are allowed to be anticipating. This gives, among other things, an essential difference between BSDEs and BSVIEs. Under some proper conditions, the well-posedness of such BSVIEs is established. Further, the results are extended to path-dependent BSVIEs, in which the generators can depend on the future paths of unknown processes. An additional finding is that for path-dependent BSVIEs, in general, the situation of anticipating generators is not avoidable, and the adaptedness condition similar to that imposed for anticipated BSDEs by Peng and Yang [Anticipated backward stochastic differential equations, *Ann. Probab.*, 37 (2009), pp. 877--902] is not necessary. Joint work with Jiongmin Yong and Chao Zhou.

OPTIMAL CONTROL OF SDES WITH MERELY MEASURABLE DRIFT: AN HJB APPROACH

Schedule: July 9 15:30-16:00 Room 619

Qingmeng Wei

Northeast Normal University, Peoples Rep of China

Abstract:

The talk is about an optimal control problem for a diffusion whose drift and running cost are merely measurable in the state variable. Such low regularity rules out the use of Pontryagin's maximum principle and also invalidates the standard proof of the Bellman principle of optimality. We address these difficulties by analyzing the associated Hamilton--Jacobi--Bellman (HJB) equation. Using PDE techniques together with a policy iteration scheme, we prove that the HJB equation admits a unique strong solution, and this solution coincides with the value function of the control problem. Based on this identification, we establish a verification theorem and recover the Bellman optimality principle without imposing any additional smoothness assumptions. We further investigate a mollification scheme depending on a parameter $\varepsilon > 0$. It turns out that the smoothed value functions V_ε may fail to converge to the original value function V as $\varepsilon \rightarrow 0$, and we provide an explicit counterexample. To resolve this, we identify a structural condition on the control set. When the control set is countable, convergence $V_\varepsilon \rightarrow V$ holds locally uniformly.

Mean-field BSDEs with quadratic growth and related control problems

Schedule: July 9 17:00-17:30 Room 619

Jiaqiang Wen

Southern University of Science and Technology, Peoples Rep of China

Abstract:

In this talk, I will present some of our recent works on general mean-field backward stochastic differential equations (BSDEs) with quadratic growth, including results on existence, uniqueness, comparison theorems, particle systems, and their relation with PDEs. Then, based on these theoretical results, I will discuss our recent work on stochastic optimal control problems and utility maximization problems.

Comparison theorems for mean-field BSDEs whose generators depend on the law of the solution (Y, Z)

Schedule: July 9 18:00-18:30 Room 619

Chuanzhi Xing

Shandong University, Peoples Rep of China

Co-Author(s): Juan Li, Zhanxin Li, Chuanzhi Xing

Abstract:

For general mean-field backward stochastic differential equations (BSDEs) it is well-known that we usually do not have the comparison theorem if the coefficients depend on the law of Z -component of the solution process (Y, Z) . A natural question is whether general mean-field BSDEs whose coefficients depend on the law of Z have the comparison theorem for some cases. In this talk we establish the comparison theorems for one-dimensional mean-field BSDEs whose coefficients also depend on the joint law of the solution process (Y, Z) . With the help of Malliavin calculus and a BMO martingale argument, we obtain two comparison theorems for different cases and a strong comparison result. In particular, in this framework, we compare not only the first component Y of the solution (Y, Z) for such mean-field BSDEs, but also the second component Z . After a discussion of mean-field BSDEs whose terminal condition and the driving coefficient are Malliavin differentiable, the results are extended in a second phase to the case without assumption of Malliavin differentiability. The talk is based on a joint work with Juan Li (SDU) and Zhanxin Li (SDU).

Maximum Principle for Partially Observed with Jump Observations and Controlled by α -Stable Lévy Processes

Schedule: July 9 15:00-15:30 Room 619

Jing Zhang

Fudan University, Peoples Rep of China

Abstract:

We establish a stochastic maximum principle for partially observed optimal control problem, in which the state dynamic is driven by an α -stable process ($1 < \alpha < 2$) and the observation process contains both Brownian and jump noises. By employing the separation principle, the original control problem is transformed into an infinite-dimensional setting, where the unnormalized conditional density of the state satisfies a fractional Zakai equation involving a fractional Laplacian and Poisson jumps. Under suitable assumptions, the well-posedness of the weak solution to the associated fractional forward-backward stochastic partial differential equation (FBSPDE) is proved within a Gelfand triple framework. The main result provides a necessary condition for optimality in the form of a Hamiltonian inequality, thereby extending earlier work to allow the control to enter the diffusion coefficient and the observation to include jumps.

The Ergodic Linear-Quadratic Optimal Control Problems with Random Periodic Coefficients

Schedule: July 9 14:30-15:00 Room 619

Qi Zhang

Fudan University, Peoples Rep of China

Co-Author(s): Jiacheng Wu, Qi Zhang

Abstract:

In this talk, I introduce our recent work on the ergodic linear-quadratic closed-loop optimal control problems with random periodic coefficients. We put forward the random periodic mean-square exponentially stable condition, and prove the random periodicity of solutions to state equation based on it. Then we prove the existence and uniqueness of random periodic solutions to two types of backward stochastic differential equations which serve as stochastic Riccati equations in the procedure of completing the square. With the random periodicity of state equation and stochastic Riccati equations, the ergodic cost functional on infinite horizon is simplified to an equivalent cost functional over a single periodic interval without limit. Finally, the closed-loop optimal controls are explicitly given based on random periodic solutions to state equation and stochastic Riccati equations.

Special Session 135 : Dynamical Systems in Mathematical Biology: Epidemiology, Population Dynamics, and Reaction Networks

Organizer(s): Burcu Gürbüz , Eugenia Franco , Nicola Vassena

Introduction: This special session aims to promote interdisciplinary dialogue and bring together researchers from various communities to develop novel insights into the dynamics of biological systems from analytical and computational perspectives. The session broadly focuses on the analysis of dynamical systems arising in mathematical biology, emphasizing the role of nonlinear differential equations in modeling complex biological behavior. Topics include stability theory, bifurcation analysis, reaction-diffusion systems, and delay differential equations, with applications ranging from biochemical reaction networks to transmission and population dynamics. The session highlights multiscale and hybrid modeling approaches, as well as data-driven techniques that link theoretical analysis with biological data.

Stoichiometric Ruin Theory: Coupling Balanced Bilinear Epidemics with Cramer-Lundberg Processes

Schedule: July 10 10:30-11:00 Room 426

Rim Adenane

University Ibn Tofail, Morocco

Abstract:

This work establishes a formal mathematical bridge between the Next-Generation Matrix (NGM) method, the celebrated cornerstone of mathematical epidemiology (ME), and the stochastic ruin theory of the Cramer-Lundberg process. Drawing on recent developments that prove the NGM is a structural outcome of the siphon property fundamental in Chemical Reaction Networks (CRN), we demonstrate how epidemiological thresholds R_0 can be mapped directly onto insurance solvency metrics. By treating the epidemic as a balanced bilinear model, we prove that the stoichiometric dwell times of the infectious compartments, a concept derived from CRN and ME, determine the asymptotic claim intensity and the adjustment coefficient of the insurer's surplus. This synthesis allows for a "stoichiometric stress test" of insurance portfolios, where financial stability is explicitly linked to the biological reaction kinetics of a pathogen.

Understanding recurrent COVID-19 outbreaks under imperfect mask protection and reinfection: a mathematical modeling study

Schedule: July 10 8:30-9:00 Room 426

Dipo Aldila

Universitas Indonesia, Indonesia

Co-Author(s): Dipo Aldila, Livia Owen, Stephen Wirana, Putri Zahra Kamalia

Abstract:

Mathematical modeling has played a key role in understanding the spread of COVID-19 and guiding public health interventions. While the effects of medical masks and reinfection have been widely studied, their interaction remains less explored. In particular, how mask usage influences reinfection dynamics can significantly alter disease outcomes but is often overlooked. In this study, we develop a transmission model that incorporates medical mask usage, reinfection, and treatment limitations. Our analysis shows that even when the basic reproduction number $\mathcal{R}_0$ is below one, the disease may still persist due to complex system behavior. This highlights that controlling COVID-19 is not always as straightforward as reducing $\mathcal{R}_0$. Through detailed numerical analysis, we uncover rich dynamics such as oscillatory outbreaks and multiple endemic states, which may explain recurring waves of infection observed in real-world data. Our results demonstrate that reinfection can fundamentally change disease dynamics, while consistent mask usage remains a crucial intervention. These findings suggest that adaptive and sustained strategies are necessary to prevent repeated outbreaks. Beyond COVID-19, this work emphasizes how combining behavioral and epidemiological factors in mathematical models can provide deeper insights for designing effective public health policies.

Compartmental disease models with time-dependent transmission parameters

Schedule: July 9 8:30-9:00 Room 426

Fatihcan M. Atay

Bilkent University, Turkey

Abstract:

We study the dynamics of compartmental disease models with time-dependent parameters. As a particular disease, we consider bacterial meningitis with two age classes and seasonal exacerbations. The time-dependent transmission parameters may represent the outbreak of meningitis cases after the annual pilgrimage period or uncontrolled inflows of irregular immigrants. We consider periodic functions in the analysis of the parameters, as well as more general non-periodic transmission processes. We derive conditions under which the long-time average values of transmission functions can be used as a stability marker of equilibria. Furthermore, we interpret the basic reproduction number in the case of time-dependent transmission functions.

Computing the competitive exclusion partition along the minimal siphons lattice, for multi-strain mathematical epidemiology models

Schedule: July 9 14:30-15:00 Room 426

Florin Avram

UPPA (retired), France

Co-Author(s): Rim Adenane, Andrei-Dan Halanay, Andras Horvath, Sei Zhen Khong

Abstract:

Our paper started as a review of three related topics. One is a recent proof of the celebrated next generation matrix (NGM) method of mathematical epidemiology (ME), which was shown recently to be an outcome of the fact that the invariance/siphon property fundamental in positive ODEs and in particular in chemical reaction networks (CRN) forces the Jacobian at any reasonable boundary equilibrium to have a triangular block form. The second topic are seven results pertaining to a family of bilinear models with rank one NGM introduced by Fall, Iggidr, Sallet and Bonzi, which utilize the explicit eigenvectors of the NGM to compute the unique endemic equilibrium (EE), and Lyapunov functions at both the disease free equilibrium (DFE) and EE. Here we clarified that the Bonzi-Iggidr-Sallet bilinear models with rank one NGM may be classified in two classes, with slight variations in the eigenvector formulas, and that extensions in the presence of feedback from infectious to susceptible are possible. The third topic are results of Shuai and Van den Driessche (2013) which essentially deal with the same DFE-EE stability exchange in the non-rank one case, when the eigenvectors are not explicit. Beyond the review, we identified another positive ODE/CRN concept, that of minimal siphons lattice, which might be useful in ME, in the direction for studying multi-strain models with multiple boundary equilibria. This work is ongoing, but it yielded already several results, as well as an algorithm implemented in our Mathematica package Epid-CRN at <https://github.com/florinav/EpidCRNmodels>, which partitions the parameter space into regions where only one boundary point may be locally asymptotically stable (LAS) (the so-called competitive exclusion partition (CEP)). All the examples in the paper have accompanying notebooks, available at the same address.

Integrating Behavioral Survey Data into Epidemic ModelsA Data-Driven Modeling Framework

Schedule: July 10 8:00-8:30 Room 426

Yogesh Bali

Johannes Gutenberg University of Mainz, Germany

Co-Author(s): Markus Schepers, Burcu G\u{u}rb\u{u}z

Abstract:

Human behavior plays a central role in shaping infectious disease transmission. As risk changes, people modify their mobility, adopt protective measures, and respond to health policies and rising case numbers. Despite this, most epidemic models still represent behavior only indirectly, either through fixed transmission parameters or by inferring behavioral effects from epidemiological trends alone. In this study, we develop a modeling framework that explicitly incorporates measured behavioral change into epidemic dynamics and enables comparison across alternative behavioral compartmental structures. Using repeated survey data from the COSMO project in Germany, we quantify variation in risk perception and protective behavior, and link these responses to policy interventions using indicators from the Oxford COVID-19 Government Response Tracker. On this basis, we construct three compartmental formulations in which behavioral change is represented through transitions between behavioral states and through behavior-dependent modulation of contact patterns and transmission intensity. Population mixing is modeled using age-structured contact matrices from POLYMOD, rescaled with time-varying mobility data from Google. All model variants are calibrated to weekly COVID-19 mortality data across 16 German states using Approximate Bayesian Computation with Sequential Monte Carlo. Our results show that explicitly incorporating behavioral dynamics improves model fit and captures regional and temporal heterogeneity effectively.

Smoluchowski coagulation equation with a flux of dust particles

Schedule: July 9 15:30-16:00 Room 426

Marina Ferreira

CNRS, University of Toulouse, France

Abstract:

The Smoluchowski coagulation equation is a classical equation describing the distribution of particle sizes undergoing binary coagulation. It arises in many areas of science, including aerosol science, molecular biology, and ecology. Despite extensive study for over a century, it continues to pose significant analytical challenges, particularly concerning long-time behavior for general coagulation kernels. Recently, an existence theory for nontrivial steady states has been developed for a large class of kernels describing coagulation in open systems. We construct a time-dependent solution that is expected to converge to a nontrivial steady state, and prove this convergence for the constant kernel with zero initial data. The solution satisfies a nonzero flux boundary condition describing a constant input of dust particles. We show that this dust is instantaneously converted into particles, so that none remains in the system, and the total mass grows linearly in time. The construction applies to a broad class of non-gelling kernels for which stationary solutions exist; in the complementary regime, no such type of solutions with flux exist. (Based on a joint work with Aleksis Vuoksenmaa - Sapienza University)

SIRS Dynamics with Waning Immunity and Periodic Revaccination

Schedule: July 10 11:00-11:30 Room 426

Burcu Gürbüz

Johannes Gutenberg-University Mainz, Germany

Abstract:

In this study, we propose an SIRS-type epidemiological model incorporating imperfect vaccination, waning vaccine-induced immunity, and periodic revaccination. Vaccinated individuals are structured by the time elapsed since their last dose, leading to a vaccination-age dependent PDE coupled to an ODE system for the remaining compartments. A discrete-time formulation yields a high-dimensional ODE model consistent with the continuous description. We analyze the equilibria and stability properties of both formulations and derive the basic reproduction number. The model exhibits backward bifurcations and bistability induced by waning immunity and revaccination, implying that disease persistence may occur even when the reproduction number is below one. Numerical continuation is used to investigate the influence of revaccination schedules and contact reduction measures. The results underline the structural role of immunity loss and demonstrate the necessity of combined vaccination and contact control strategies.

On the Dynamics of a Two-Strain Dengue System with Secondary Infection-Induced Mortality

Schedule: July 9 15:00-15:30 Room 426

Aytul Gokce

Ordu University, Turkey

Co-Author(s): Joseph Paez Chavez, Thomas Gotz, Burcu Gurbuz

Abstract:

Dengue fever is among the most prevalent vector-borne diseases worldwide. In this work, we propose and analyze a deterministic two-strain host-vector model for dengue transmission. The human population is structured into primary and secondary infection classes, while the mosquito population is divided into single- and co-infected compartments. The model incorporates temporary cross-immunity, mortality during secondary infections, antibody-dependent enhancement (ADE), and explicit mosquito co-infection. ADE is represented through distinct transmission rates for primary and secondary infections. Using the next-generation matrix approach, we derive the basic reproduction number, R_0 , and establish the local stability of the disease-free equilibrium when $R_0 < 1$. We show that specific ADE conditions can destabilize one-strain endemic equilibria, enabling invasion by a heterologous strain. Center-manifold analysis and numerical continuation further reveal backward bifurcation, bistability, and Hopf-induced oscillations, emphasizing complex dynamics relevant to dengue control strategies.

Mathematical Modeling of Regulatory Dynamics and Viral Pathogenesis in T-Cell Mediated Immune Responses

Schedule: July 9 17:30-18:00 Room 426

Meltem Golgeli

TOBB University of Economics and Technology, Turkey

Co-Author(s): Kaan Karaser

Abstract:

The progression of viral infections is determined by the dynamic interplay between viral replication strategies and the host's adaptive immune response. Central to this process is the balance between effector T-cell activation and the induction of regulatory mechanisms that, while preventing excessive tissue damage, may inadvertently facilitate viral persistence. Understanding the non-linear transitions within these regulatory feedback loops is essential for identifying the biological triggers of viral pathogenesis. In this talk, we propose a mathematical framework based on a system of non-linear ordinary differential equations (ODEs) to investigate the interactions between viral load, effector cell populations, and regulatory signaling pathways. The model incorporates specific transcription factor-mediated dynamics that govern the suppressive modulation of the immune response throughout the infection process. We conduct a rigorous qualitative analysis, including the determination of steady states and their stability, to identify parameter thresholds where the system undergoes significant regime shifts. Our findings highlight critical parameters, such as the suppression rate of effector populations, which act as primary drivers for the transition between viral clearance and immune escape. This model is specifically applied to and validated against viral pathogenesis data, providing mechanistic insights into potential therapeutic interventions and the complex dynamics of viral-host co-evolution.

Allee-Driven Thresholds and Bifurcation Structure in Cancer Immunoediting.

Schedule: July 9 9:30-10:00 Room 426

Eymard Hernandez-Lopez

University of Tennessee at Chattanooga, USA

Abstract:

This work explores a mathematical model of tumor-immune interactions that incorporates Allee effects to capture the nuances of cooperative tumor growth. Through bifurcation analysis and numerical continuation, we identify and characterize saddle-node, Hopf, Bautin, and Bogdanov-Takens bifurcations, further establishing a formal proof of a codimension-three bifurcation within a biologically relevant parameter space. The findings provide a theoretical foundation for understanding the critical transitions between the elimination, equilibrium, and escape phases of cancer immunoediting, highlighting the underlying mechanisms that drive clinical outcomes.

New oscillatory regimes for competing predators with Holling type II response

Schedule: July 10 12:00-12:30 Room 426

Phillipo Lappicy

Universidad Complutense de Madrid, Spain

Co-Author(s): K. E. M. Church, J.-Y. Dai, O. H\'enot, A. L\'opez-Nieto, H. Stuke, N. Vassena.

Abstract:

Oscillatory regimes typically arise from the presence of periodic orbits in dynamical systems. We present three new results for models of competing predators with Holling type II functional response. First, we introduce a new mechanism that generates periodic orbits, which we call hybrid bifurcations: a classical bifurcation occurring at a bifurcation without parameters. We establish existence and stability criteria for the bifurcating periodic solutions and obtain stable periodic coexistence states far from extinction regimes, where all populations remain bounded away from zero. Second, we prove global continuation and stability of families of periodic orbits with respect to a parameter using a computer-assisted framework. As a consequence, we solve a conjecture of Butler and Waltman (1981) concerning one-parameter families of periodic orbits connecting two extinction regimes. Finally, we analyze a candidate Poincar\'e return map for these systems. Using computer-assisted techniques, we prove the existence of periodic orbits together with associated period-doubling bifurcations, indicating a transition to a chaotic regime.

Controlling dynamics of complex biological systems based on network topology

Schedule: July 9 13:30-14:00 Room 426

Atsushi Mochizuki

Institute for Life and Medical Sciences, Kyoto University, Japan

Co-Author(s): Atsushi Mochizuki

Abstract:

Dynamics of gene activities based on gene regulatory networks are the origin of biological functions. To understand dynamics of complex systems, we developed Linkage Logic theory by which important aspects of dynamics are determined from topology of regulatory network alone. The theory assures that i) any dynamical behavior of whole system can be identified/controlled by a subset of nodes in a regulatory network, and ii) the subset is determined from topology of the network as a feedback vertex set (FVS). We applied the theory to gene regulatory network for ascidian development including >90 genes. We verified our prediction by experimental manipulation of six genes, and confirmed deterministic induction of each of all seven tissues, respectively. To expand the practical power of Linkage Logic, we also developed new estimation method for gene regulatory networks called RENG, where genes are perturbed comprehensively and resulting changes in gene expression are measured as a time series. This method makes it possible to distinguish between direct and indirect regulations. This method was applied to human iPS cells, and a gene network containing 103 genes for pluripotency was estimated. We are currently working on fate control of human iPS cells by manipulating FVS of the network.

On Reaction-Diffusion-Taxis Systems in Eco-Epidemiology

Schedule: July 10 9:00-9:30 Room 426

Nishith NM Mohan

RPTU Kaiserslautern-Landau, Germany

Co-Author(s): Nishith Mohan

Abstract:

We investigate the role of taxis mechanisms in eco-epidemiological systems, i.e., models that integrate both ecological interactions and disease dynamics. The inclusion of taxis makes the model more nuanced but introduces significant analytical challenges by imparting a cross-diffusive structure. The mathematical analysis is carried out through the development of an energy-based argument, similar to that for the chemotaxis Keller-Segel system, and we demonstrate that it can be adapted to this broader framework. By exploiting the underlying energy structure, we establish global existence and boundedness of solutions under certain spatial and parametric restrictions. These results highlight the efficacy of energy-like approaches in handling complex coupled systems arising in mathematical biology.

A reaction-diffusion model of resistance development in diploid organisms

Schedule: July 10 9:30-10:00 Room 426

Luca Nieding

Technical University Braunschweig, Germany

Abstract:

The development of metabolic resistance complicates the treatment of economic plants with herbicides and is not yet fully understood. We present a population-dynamic 2D reaction-diffusion equation as a polygenic fitness model for the development of metabolic resistance. We explore the general dynamics due to inheritance as a reaction term and its interaction with spatial spread. Further, we construct a family of submodels and investigate the hierarchy of the modelled effects. As a consequence to the application in agriculture, we numerically investigate the effects of spatial barriers on the dynamics.

Structural Determination of Bifurcation and Multistability in Chemical Reaction Networks

Schedule: July 10 11:30-12:00 Room 426

Takashi Okada

Hiroshima University, Japan

Abstract:

In living cells, numerous reactions are interconnected through shared substrates and products, thereby forming complex reaction networks. The dynamics of such networks remain insufficiently understood, largely because the quantitative forms of reaction-rate functions are often unknown. To address this difficulty, one can adopt a structural or topological approach that does not rely on detailed kinetic assumptions or specific parameter values. Here, we present our recent studies on structural methods that enable us to determine bifurcation properties of chemical reaction systems directly from network structure, including which parameters control the onset of bifurcations and which parts of the system exhibit bifurcating behavior. We further discuss multistability, focusing in particular on a structural criterion for identifying the molecular species that should be observed to distinguish and classify coexisting steady states.

An epidemiological model describing co-infection of HIV/AIDS and COVID-19 considering public awareness and prevention

Schedule: July 9 8:00-8:30 Room 426

Joseph Paez Chavez

Escuela Superior Politecnica del Litoral, Ecuador

Co-Author(s): D. Aldila, B. Nugroho, B. Omede, O. James, P. Kamalia

Abstract:

This presentation proposes a mathematical model describing the simultaneous transmission of HIV and COVID-19, explicitly incorporating COVID-19 vaccination and public awareness. The model is analytically examined to determine the existence and local stability of equilibria for both single-infection and co-infection scenarios. Results show that each disease persists in isolation when its basic reproduction number exceeds one. For the co-infection framework, the overall reproduction number is governed by the larger of the individual reproduction numbers for HIV and COVID-19. Numerical continuation reveals thresholds that allow both diseases to coexist, while disease-free stability requires both reproduction numbers to be below one. A two-parameter continuation analysis shows that the condition where both reproduction numbers equal one serves as an organizing center for various (co-)infection scenarios.

Computational approaches to inheritance of dynamics in reaction networks

Schedule: July 10 13:30-14:00

Casian Pantea

West Virginia University, USA

Abstract:

Recent work by Banaji and collaborators shows that certain enlargements of reaction networks --through the addition of species and reactions-- preserve key dynamical properties such as multistationarity, oscillations, and bifurcations. This framework enables the use of certificates for specific behaviors (e.g., a supercritical Hopf bifurcation) by reducing analysis to smaller, more tractable subnetworks. In principle, this allows one to answer the question ``Does a network $\mathcal{N}$ exhibit dynamical property X ? by identifying a smaller network $\mathcal{M}$ with property X and a sequence of enlargements from $\mathcal{M}$ to $\mathcal{N}$. In this talk, we investigate algorithms for tackling this combinatorially explosive problem and present real-world applications of inherited Hopf bifurcation in large enzymatic networks.

PerTexP: scenario-based exploration of pertussis dynamics under maternal and infant vaccination

Schedule: July 9 18:00-18:30 Room 426

Emanuela Penitente

University of Naples Federico II, Italy

Co-Author(s): Anna Autoriello, Sabrina Averga, Bruno Buonomo, Rossella Della Marca, Alfredo Guarino, Cristina Moracas, Emanuela Penitente, Marco Poeta

Abstract:

Despite the widespread availability of effective vaccines, pertussis remains a significant public health concern in many high-income countries, particularly because of its severe impact on infants. In recent decades, several regions have experienced a resurgence of pertussis, with recurrent outbreaks and an overall increase in incidence \cite{yeung2017update}. These patterns highlight the need for modelling tools that are both mathematically rigorous and accessible to health practitioners, supporting the exploration of intervention scenarios and evidence-based planning. To this end, we present PerTexP (Pertussis Time Exploration), an interactive MATLAB tool for scenario-based analysis of pertussis transmission under different vaccination strategies \cite{buonomo2025pertexp}. PerTexP is based on a discrete-time, stage-structured compartmental model with two age classes, infants and non-infants, and explicitly incorporates maternal immunisation, infant vaccination, and booster doses in older individuals. Through a graphical user interface, the tool allows users to compare vaccination scenarios and assess their impact on transmission. Applied to the 2024 Italian pertussis outbreak \cite{poeta2024pertussis}, PerTexP suggests an increasing burden over a five-year horizon and shows that increasing maternal coverage yields a larger reduction in cumulative incidence than an equivalent increase in booster uptake, while elimination requires strengthening both interventions.

\begin{thebibliography}{99} \bibitem{buonomo2025pertexp} Autoriello, A. et al. (2026). PerTexP: scenario-based exploration of pertussis dynamics under maternal and infant vaccination. medRxiv, 2026-03. \bibitem{poeta2024pertussis} Poeta, M. et al. (2024). Pertussis outbreak in neonates and young infants across Italy, January to May 2024: implications for vaccination strategies. Eurosurveillance, 29(23), 2400301. \bibitem{yeung2017update} Yeung, K. H. T. et al. (2017). An update of the global burden of pertussis in children younger than 5 years: a modelling study. The Lancet Infectious Diseases, 17(9), 974-980.

Delayed immune response and therapy in tumor-immune dynamics

Schedule: July 9 18:30-19:00 Room 426

Ana Jacinta Soares

Centre of Mathematics, University of Minho, Portugal

Co-Author(s): L. Boudjellal. M. J. Torres.

Abstract:

We present and analyse a mathematical model describing tumor-immune interactions. The model incorporates the effects of adoptive cellular immunotherapy and includes a delay term accounting for the time lag in the adaptive immune response following tumor recognition. We also consider a non-autonomous extension modelling time-dependent targeted therapy. We investigate the qualitative behaviour of the model, including well-posedness, equilibrium states and their stability, and analyse how the delay and therapy influence the system dynamics. In particular, we show that the delay may induce stability switches, while time-dependent therapies can significantly affect the long-term behaviour of the solutions. Numerical simulations are presented to illustrate the theoretical results and to investigate the impact of the targeted therapy, supported by parameter estimation from experimental data. This is joint work with Laid Boudjellal and Maria Joana Torres.

Starvation-driven cell patterning: integrating lab experiments and mathematical modelling

Schedule: July 9 17:00-17:30 Room 426

Cinzia Soresina

University of Trento, Italy

Abstract:

We present a reaction-diffusion model describing the interactions among cells, nutrients, and growth factors, aimed at capturing the emergence of starvation-driven cell pattern formation, a phenomenon recently observed in laboratory experiments under nutrient-limited growth conditions. Experiments and modelling were developed in parallel, enabling progressively more targeted experimental design while enhancing the biological realism of the model. This interdisciplinary feedback loop led to the formulation of new hypotheses and enabled the estimation of several key parameters. Numerical simulations show that the model reproduces pattern formation in both one- and two-dimensional spatial domains. To provide theoretical support for these findings, we performed a Turing instability analysis to investigate the potential for diffusion-driven instability. The analysis indicates that the observed patterns are not driven by chemotaxis; rather, they arise naturally under starvation conditions and display structural similarities to the Klausmeier model for vegetation pattern formation in semi-arid environments, suggesting the robustness of the underlying mechanism across biological scales.

The Influence of Climate Variability on Ebola Spread: A Dynamical Systems Approach with Environmental Reservoir and Viral Ecology

Schedule: July 9 9:00-9:30 Room 426

Calvin Tadmon

University of Dschang, Cameroon

Abstract:

Ebola virus disease (EVD) is an overwhelming haemorrhagic fever causing serious threats to human health, with outbreaks frequently linked to a spillover from wildlife reservoirs. Climatic factors are suspected to influence EVD transmission. However, the mechanisms by which this proceeds remain poorly understood. The aim of this talk is to quantify the effects of some climatic drivers such as temperature and rainfall on the spread of EVD. We consider direct and indirect routes of contamination between and within human and fruit bat populations, and model the transmission dynamics of the disease as a system of nonlinear ordinary differential equations, where some key climate-dependent parameters are incorporated as functions of temperature and rainfall. The nonautonomous differential system derived is completely analysed. To begin with, we neglect the intra-annual variation of climate, and investigate the corresponding autonomous system obtained. The basic reproduction number is computed, and the existence and stability of equilibria are successfully studied. Sensitivity analyses highlight, among others, the critical role of environmental transmission and cross-species contamination. Secondly, the nonautonomous model is thoroughly investigated by mainly relying on the definition of the basic reproduction number in periodic environments. We prove the existence, uniqueness and global stability of a positive Ebola-free solution. Finally, to illustrate the theoretical findings, we perform some numerical simulations using real climate data from the locality of Beni (Democratic Republic of Congo). Our results reveal that temperature and rainfall can actually influence the spread of EVD. The present investigation provides a quantitative framework linking climate change to Ebola virus ecology, and a valuable tool for public health planning in climate vulnerable regions.

Invading activity fronts stabilize excitable systems against stochastic extinction

Schedule: July 9 16:30-17:00 Room 426

Uwe C Tauber

Physics Department, Virginia Tech, USA

Co-Author(s): Kenneth Distefano, Sara Shabani

Abstract:

Stochastic chemical reaction or population dynamics in finite systems often terminates in an absorbing state. Yet in large spatially extended systems, the time to reach species extinction (or fixation) becomes exceedingly long. Tuning control parameters may diminish the survival probability, rendering species coexistence susceptible to stochastic extinction events. In inhomogeneous settings, where a vulnerable subsystem is diffusively coupled to an adjacent stable patch, the former is reanimated through continuous influx from the interfaces, provided the absorbing region sustains spreading activity fronts. We demonstrate this generic elimination of finite-size extinction instabilities via immigration flux in predator-prey, epidemic spreading, and cyclic competition models.

Dynamical consequences of autocatalysis in reaction networks

Schedule: July 10 14:00-14:30

Nicola Vassena

Leipzig University, Germany

Abstract:

Autocatalysis is a fundamental mechanism for self-amplification and positive feedback in reaction networks. Using a structural (i.e., network-based) definition, autocatalysis provides a sufficient condition for a network to admit an unstable equilibrium. More specifically, a Perron-Frobenius argument links autocatalysis to a possible positive growth of the system. Albeit with different wording, bifurcations in epidemiological networks are most naturally a consequence of autocatalysis too (see e.g. works by Adenane and Avram, also participating in this special session). In this talk I will overview such ideas and present examples of reaction networks where multistationarity (including co-existence of stable equilibria) and periodic oscillations are triggered by autocatalysis. I will also discuss how autocatalysis is a natural, but not exhaustive, route to instability, and show examples where non-autocatalytic forms of instability arise.

Non-monotonic dose-response curves in biochemical systems

Schedule: July 9 14:00-14:30 Room 426

Polly Y. Yu

University of Illinois Urbana-Champaign, USA

Co-Author(s): Eduardo D. Sontag

Abstract:

A response curve measures the output of a biological system at equilibrium against an input parameter, which could be a rate constant, the dose of a ligand, or the strength of an external signal. While often monotonic, a response curve that is biphasic serves as a mechanism against over-activation. For example, it has been observed that a T-cell's response to antigen concentration is non-monotonic. It has been conjectured that an incoherent feedforward loop is necessary to explain biphasic response. In this talk, we establish necessary conditions for biphasic response for general non-linear systems. More precisely, we proved that either an incoherent feedforward loop, or a combination of positive and negative feedback loops, is necessary for biphasic response.

Special Session 136 : Collective Dynamics in Large Networks: From Kuramoto to Spin Models

Organizer(s): Georgi Medvedev , Nils Berglund , Matthew Mizuhara

Introduction: Collective dynamics in large networks has been a subject of intense research in both the nonlinear science and statistical physics communities, often approached in different contexts and driven by different motivations. A striking example is the study of synchronization and metastability in the Kuramoto model of coupled phase oscillators, which is also known as the XY spin model in statistical physics. The goal of this session is to bridge the two fields by fostering the exchange of ideas and highlighting recent advances in both areas.

XY-model meets graphons

Schedule: July 9 15:00-15:30 Room 437

Artem Alexandrov

Steklov Institute of Mathematics, Russia

Abstract:

Initially developed as limiting objects that describe large networks, graphons laid the foundation to consider generalizations of mean-field spin models, like Ising model or XY-model. Statistical physics tells us that the thermodynamic limit is crucial to study phase transitions and other critical phenomena. For dense (and not so dense) graphs, this limit can be described with help of graphons or L^p -graphons. I will show how to use graphons to analyze phase transitions in XY model and its generalization with quenched disorder. Graphons provides a simple tool for derive and solve self-consistency equations by analyzing the spectrum of related functional operators. Moreover, for certain graphons, we can observe metastability or so-called transient states. To illustrate these statements, we discuss the Kuramoto model in the context of polariton arrays.

Mean-field limits for interacting particle systems on adaptive dynamical networks

Schedule: July 9 14:30-15:00 Room 437

Nathalie Ayi

Sorbonne Universite, France

Abstract:

A central distinction in interacting particle systems is between indistinguishable and non-exchangeable cases. In the latter, particle identity plays a key role, and interactions are naturally modeled by systems of ODEs on weighted graphs. In this talk, we study such systems and their large-population behavior, highlighting the connection between graph limit and mean-field approaches. Our main focus is on systems evolving on adaptive dynamical networks, where agents interact through weighted graphs whose structure evolves over time in a coupled manner with the agents' states. In the dense-graph regime, we show that the large-population limit is described by a Vlasov-type equation posed on an extended phase space including agent states, identities, and evolving interaction weights. We present two complementary derivations of this limit: a mean-field approach in the spirit of Sznitman's work, under a structural assumption on the weight dynamics, and a deterministic graph limit approach that allows us to remove this restriction.

Kuramoto's Energy Landscape in random geometric graphs.

Schedule: July 10 8:00-8:30 Room 437

Pablo Groisman

Universidad de Buenos Aires, Argentina

Abstract:

We'll consider the energy function of the Kuramoto model in random geometric graphs on a given manifold, with particular focus on the d -dimensional torus and the 2-sphere. As the number of nodes diverges, with high probability there are no (smooth) local minima other than the phase-locked state in the case of the sphere, while in the torus there is at least one local minimum for each homotopy class of continuous functions from the manifold to the circle. This is proved for $d = 1$ and conjectured for every $d > 1$. We'll then specialize to the cycle graph, where we can go beyond existence and describe the volume and geometry of the basins of attraction of each twisted state, shedding light on the long-time behavior of the system.

Critical threshold for synchronizability of high-dimensional Kuramoto oscillators under higher-order interactions

Schedule: July 9 18:00-18:30 Room 437

Dohyun Kim

Sungkyunkwan University, Korea

Co-Author(s): Hyungjin Huh

Abstract:

Collective synchronization in the Kuramoto model has been widely studied, but the original model is defined on the unit circle and only includes pairwise interactions. In this presentation, based on [Huh and Kim, Chaos (2024), 123119], we study a high-dimensional Kuramoto model with both two-body and three-body interactions. Let κ_1 and κ_2 denote the corresponding interaction strengths. We show that complete synchronization can emerge if $\kappa_1 + \kappa_2 > 0$, whereas it cannot occur if $\kappa_1 + \kappa_2 < 0$. In the critical case $\kappa_1 + \kappa_2 = 0$, the emergence of synchronization depends crucially on the sign of κ_1 , and critical slowing down is observed at the threshold. Our analysis provides a rigorous characterization of the critical line suggested in [Kovalenko et al., Phys. Rev. Lett. (2021), 258301]. Numerical experiments complement the theory and reveal additional qualitative behaviors.

Adaptive and Higher-Order Dynamics of Kuramoto-type Models

Schedule: July 9 16:30-17:00 Room 437

Christian Kuehn

TUM, Germany

Abstract:

In my talk I shall provide a short survey of recent results I have obtained with a number of co-authors on considering Kuramoto-type models, where adaptive (or co-evolutionary) and higher-order (or polyadic) aspects play a key role. In particular, I shall discuss structural issues (e.g., how do simplicial and non-simplicial aspects form adaptively or arise via modelling), mean-field limits (on graph limits), as well as solutions to the resulting bifurcation problems. This highlights the importance of combining different mathematical approaches to understand Kuramoto-type models from first principles up to eventually understanding their complex dynamics.

Interacting dynamical systems on self-similar networks

Schedule: July 10 9:00-9:30 Room 437

Georgi Medvedev

Drexel University, USA

Abstract:

We develop a continuum limit and mean-field theory for interacting particle systems (IPS) on self-similar networks, a new class of discrete models whose large-scale behavior gives rise to nonlocal evolution equations on fractal domains. This work extends the graphon-based framework for IPS, used to derive continuum and mean-field limits in the non-exchangeable setting, to situations where the spatial domain is fractal rather than Euclidean. The motivation arises from both physical models naturally formulated on fractals and real-world networks exhibiting hierarchical or quasi-self-similar structure. The main result of this work is an explicit isomorphism between self-similar IPS and graphon IPS, which allows us to justify the continuum and mean-field limits in the self-similar setting.

Twisted states of Kuramoto oscillators on self-similar sets

Schedule: July 9 13:30-14:00 Room 437

Matthew Mizuhara

The College of New Jersey, USA

Abstract:

Coupled phase oscillators provide a prototypical setting for studying spontaneous synchronization and other pattern formation. The interplay between network topology and emergent phenomena remains a central theme in their study. Some real-world networks, such as coupled neurons and the Internet, exhibit self-similarity at multiple scales, so there is a need to analyze coupled oscillators on hierarchical/fractal structures. To that end, we study Kuramoto oscillators on self-similar networks approximating fractals. We show that the complex topology of fractals gives rise to a rich diversity of equilibria, generalizing well-studied twisted states found on simpler networks. We introduce an approach for constructing and classifying these states by combining tools from fractal geometry, topology, and analysis. Our method relies on harmonic extensions, which provide exact solutions to the Laplace equation on the fractal, and uses T-convergence to establish convergence of the nonlinear problems. This work is in collaboration with Georgi Medvedev and is supported by the U.S. National Science Foundation.

Mean-field approach to finite-size fluctuations in coupled oscillator systems

Schedule: July 9 17:00-17:30 Room 437

Oleh Omelchenko

University of Potsdam, Germany

Co-Author(s): Oleh Omel'chenko and Georg Gottwald

Abstract:

Networks of coupled phase oscillators are one of the most studied dynamical systems with numerous applications in physics, chemistry, biology, and engineering. A variety of methods exists to explain their properties and dynamics in the thermodynamic limit, when the network size tends to infinity. However, the behavior of such systems in the more realistic case of a finite number of oscillators still remains poorly understood. In this talk, we revisit the paradigmatic Kuramoto-Sakaguchi model describing synchronization transitions in networks of all-to-all coupled heterogeneous phase oscillators, and propose an ab initio approach for characterizing analytically the statistical properties of finite-size fluctuations in this system. Our framework is applicable to any stationary partially synchronized state and does not require any prior knowledge about its structure. Moreover, it is sufficiently general such that it can be applied to a broader class of interacting particle systems.

Formation of clusters and coarsening in weakly interacting diffusions

Schedule: July 9 14:00-14:30 Room 437

Grigorios A Pavliotis

Imperial College London, England

Co-Author(s): Nicolai Gerber, Rishabh Gvalani, Martin Hairer, Andre Schlichting

Abstract:

We study the clustering behavior of weakly interacting diffusions under the influence of sufficiently localized attractive interaction potentials on the one-dimensional torus. We describe how this clustering behavior is closely related to the presence of discontinuous phase transitions in the mean-field PDE. For local attractive interactions, we employ a new variant of the strict Riesz rearrangement inequality to prove that all global minimizers of the free energy are either uniform or single-cluster states, in the sense that they are symmetrically decreasing. We analyze different timescales for the particle system and the mean-field (McKean-Vlasov) PDE, arguing that while the particle system can exhibit coarsening by both coalescence and diffusive mass exchange between clusters, the clusters in the mean-field PDE are unable to move and coarsening occurs via the mass exchange of clusters. By introducing a new model for this mass exchange, we argue that the PDE exhibits dynamical metastability. We conclude by presenting careful numerical experiments that demonstrate the validity of our model.

Stability analysis of Kuramoto model with time delay via a generalized spectral theory

Schedule: July 9 17:30-18:00 Room 437

Haozhe Shu

Tohoku university, Japan

Co-Author(s): Haozhe Shu

Abstract:

Known as a relatively simple mean-field model of coupled phase oscillators, the Kuramoto model plays an important role in studying the collective synchronization phenomenon. In this talk, the linear stability of incoherent state to the continuum limit of the Kuramoto model with time delay is investigated. Here, it is known that due to the presence of continuous spectrum on the imaginary axis, stability analysis meets obstacles even if no eigenvalue exists on the right complex half-plane. To address it, a generalized spectral theory on a Gelfand triple is utilized. Under some analyticity condition, resolvent operator is extended to a generalized resolvent. It is shown that continuous singularities (continuous spectrum) disappear from the Riemann surface of the generalized resolvent due to the change of topology via the Gelfand triple. Then, the contour deformation is applied in the inverse Laplace representation to show stability in a weak topology.

Numerical Methods for Stochastic McKean-Vlasov Equations

Schedule: July 10 8:30-9:00 Room 437

Gideon Simpson

Drexel University, USA

Abstract:

We study numerical schemes for integrating the stochastic McKean-Vlasov equations, with goals of both identifying metastable states and sampling from equilibrium. In particular, the metastable solutions may correspond to invariant distributions of the underlying interacting particle system. This is the case when the metastable solutions are finite temperature analogs of time independent solutions to the zero temperature McKean-Vlasov. This is joint work in collaboration with M. Ottobre.

Special Session 137 : Nonlinear Dynamics, Chaos, and Applications: From Fractional Systems to Astrophysical Models

Organizer(s): Mattia Cocco, Juan Carlos Vallejo

Introduction: This special session will explore the frontiers of nonlinear dynamics and chaos in a broad and interdisciplinary context, with an emphasis on both foundational advances and real-world applications. We aim to bring together researchers from diverse fields including physics, mathematics, engineering, computational neuroscience, quantum systems, and astrophysics, to present and discuss novel approaches to complex dynamical phenomena. Topics will include recent developments in fractional-order systems, synchronization and resonance phenomena in coupled oscillators, nonlinear modeling of neural activity, unpredictability in quantum and classical systems, and complex dynamics in astrophysical scenarios. A special focus will be given to: The role of fractional derivatives in describing memory and hereditary effects in physical and biological systems. Delay-induced phenomena and resonance in nonlinear and stochastic systems. Quantum chaos and classical-quantum correspondence. Astrophysical chaos, including orbital dynamics, escape basins, scattering phenomena and unpredictability in galactic models. Neural models (e.g., FitzHugh–Nagumo, Rulkov) and their bifurcation and synchronization patterns. Other topics of interest include (but are not limited to): Chaos and complexity in nonlinear dynamical systems Synchronization in coupled oscillators and networks Control and predictability of chaotic dynamics Neuronal dynamics and bursting behavior Chaotic scattering and escape basin structures Lyapunov-based methods and phase space analysis

Controlling the dynamics of a superconducting sphere inside superfluid He-II

Schedule: July 9 17:30-18:00 Room 315

Manuel Arrayas

Universidad Rey Juan Carlos, Spain

Co-Author(s): J. L. Trueba, C. Uriarte

Abstract:

Since that pioneering time, the use of electromechanical probes to test the quantum features of superfluidity has been the workhorse of ultra-low-temperature research. Superfluids exert forces on objects through added mass, normal-fluid drag, mutual friction with vortices, and emission of excitations (phonons and rotons). Electromechanical resonators such as torsional oscillators, vibrating wires, quartz tuning forks, and other microelectromechanical devices (MEMS), because of changes in frequency, damping, and electrical response, provide very sensitive signatures of superfluid flow, quasiparticles, and broken symmetries. However, most of these probes suffer from boundary effects, as they must be attached to the walls of experimental cells. Moreover, the type of motion they allow one to explore is limited mainly to oscillatory motion. Thus, the search began for a dynamical, non-contact electromechanical probe that would allow one to separate intrinsic mechanical losses from fluid-induced ones. These requirements naturally lead to levitation. A levitated object has no mechanical suspension, so there are no clamping losses. However, controlling the dynamics of a levitated object poses additional challenges that we will analyse.

Fractional damping term in nonlinear oscillators.

Schedule: July 9 9:00-9:30 Room 315

Mattia Cocco

Universidad rey Juan Carlos, Spain

Co-Author(s): Mattia Cocco

Abstract:

Fractional-order damping provides a compact way to incorporate memory effects into nonlinear dynamical models beyond instantaneous viscous dissipation. In this talk we investigate how introducing a fractional derivative in the dissipative term reshapes both transient evolution and asymptotic dynamics in nonlinear systems, with the fractional order α as a control parameter. Through systematic numerical experiments, we quantify changes in the time required to reach the long-term regime (e.g., convergence to attractors, well-to-well transitions, or escape events) and compare behaviors across parameter ranges that are classically underdamped and overdamped. The results show that memory can qualitatively reorganize the effective damping landscape: regimes that are simple in the integer-order overdamped limit may become structurally richer when α is varied, with altered thresholds and enhanced sensitivity in parameter space. In addition, fractional dissipation can promote resonance-like amplification and frequency-selective responses without modifying the conservative part of the dynamics, providing a new tuning mechanism for nonlinear response. The presented viewpoint is general and can be extended to coupled oscillators and excitable systems.

Predictive-Switching Control of Stochastic Biochemical Oscillators and Toggle Switches with Contractivity Analysis

Schedule: July 9 13:30-14:00 Room 315

Christian Fernandez Perez

I2SYSBIO-CSIC, Spain

Co-Author(s): Christian Fernandez, Manuel Pajaro, Gabor Szederkenyi, Irene Otero-Muras

Abstract:

Stochastic biochemical oscillators, such as genetic toggle switches, exhibit complex dynamics due to intrinsic molecular noise and low molecular counts. While the Chemical Master Equation (CME) provides a rigorous probabilistic description, it is often computationally intractable; Partial Integro-Differential Equation (PIDE) models offer a tractable alternative with solid theoretical foundations. We introduce the Predictive-Switching Controller (PSC), a model-based strategy that evaluates system trajectories under a finite set of input configurations and selects the one optimizing a cost functional. This framework can stabilize low-probability states, preserve transient bimodality, and reshape complex distributions. To accelerate high-dimensional computations, a neural network predicts optimal input actions, maintaining the reliability of the model-based approach. A key theoretical contribution is the proof of L1-contractivity of the PIDE dynamics, ensuring that probability distributions under fixed control profiles remain bounded and are robust to variations in initial conditions. We validate PSC on stochastic toggle-switch networks, demonstrating its ability to maintain unstable states and modulate bimodal distributions effectively. These results highlight PSC as a flexible, robust, and computationally efficient method for controlling stochastic biochemical oscillators, with potential applications in synthetic biology and the design of robust genetic circuits.

Some remarks on Melnikov chaos for smooth and piecewise smooth systems

Schedule: July 9 14:00-14:30 Room 315

Matteo Franca

University of Florence, Italy

Co-Author(s): Calamai, A; Pospisil M.

Abstract:

It is well known that a smooth autonomous system which has a homoclinic trajectory (i.e. a trajectory converging to a critical point as $t \rightarrow \pm\infty$), and subject to a small periodic forcing, may exhibit a chaotic pattern. A motivating example in this context is given by a forced inverted pendulum. Melnikov theory provides a computable sufficient condition for the existence of a transversal intersection between stable and unstable manifolds: in a smooth context this is enough to guarantee the persistence of the homoclinic trajectory and the insurgence of chaos. In this talk we show that, in piecewise smooth system with a transversal homoclinic point, a generic geometrical obstruction forbids chaotic phenomena which are replaced by new bifurcation scenarios. Further, if this obstruction is removed, chaos may arise again. Piecewise smooth systems are motivated by the study of dry friction, state dependent switches, or impacts. In fact we will also show some results new in a smooth context, concerning multiplicity, position, and size of the Cantor set $\mathcal{N}$ of initial conditions from which chaos emanates. In particular we will see that, even if the perturbation is $O(\varepsilon)$, we may find infinitely many distinct Cantor set $\mathcal{N}$ located in the same $O(\varepsilon^\nu)$ neighborhood of the critical point, each corresponding to a different pattern, and where $\nu > 1$ is as large as we wish. Further the classical requirement that the trajectories stay $O(\varepsilon)$ close to the critical point, might be replaced by staying $O(\varepsilon^\nu)$ close to the critical point, again $\nu > 1$ can be chosen arbitrarily large.

From discrete to continuous modeling and from continuous to discrete modeling in gas-like models in Econophysics

Schedule: July 9 17:00-17:30 Room 315

Ricardo Lopez-Ruiz

Univ of Zaragoza, Spain

Co-Author(s): Ricardo Lopez-Ruiz

Abstract:

We explore the two-way path of modeling in Econophysics. From one side, it is possible to go from the discrete model proposed by Dragulescu and Yakovenko (in the 2000's) to the continuous Z-model proposed and studied by Lopez-Ruiz and collaborators (in the 2010's). On the other side, it is possible to go from the continuous modified Z-model proposed by Pomeau and Lopez-Ruiz (in the 2015's) to the discrete model recently proposed and studied by Breton-Fuertes and Lopez-Ruiz (in the 2025's). The properties and derivations of these models will be displayed and shown in this oral communication.

Modeling Pandemics in an Age-Structured Population

Schedule: July 9 8:30-9:00 Room 315

GUSTAVO A Munoz-Fernandez

Universidad Complutense de Madrid, Spain

Abstract:

We present a dynamical system that models the long-term impact of a pandemic on a population structured by age. Our analysis focuses on deriving the basic reproduction number to gain qualitative insight into the stability of the disease-free equilibrium states. This quantity, obtained through the next-generation matrix framework, serves as a key threshold parameter that determines whether an infection can invade and persist within the population. The methodology provides a rigorous mathematical foundation for understanding how age-dependent contact patterns, susceptibility, and demographic processes influence disease dynamics. This approach not only clarifies the role of population structure in shaping epidemic trajectories but also offers a systematic way to evaluate potential intervention strategies. Other aspects, such as the effect of vaccination, can also be incorporated and analyzed within this framework.

Forced chaotic scattering

Schedule: July 9 8:00-8:30 Room 315

Jesus M Seoane

Universidad Rey Juan Carlos, Spain

Abstract:

In this talk, we present a study of the phenomenon of chaotic scattering under periodic forcing. Previous works showed that the frequency value $\omega = 1$ was the optimal value for which particles escaped from the scattering region in the fastest way. Similarly, for the relativistic regime, the study was conducted in the context of a rotating external force where, depending on the value of the external frequency, both fast and slow escapes were observed. Here, we also study quantitative indicators such as SALI or finite-time Lyapunov exponents, but for the case of non-autonomous systems, specifically, those subjected to periodic forcing, which provide local information about the behavior of trajectories as a function of the forcing frequency and amplitude.

Stochastic resonance in time-delayed bistable active particles

Schedule: July 9 16:30-17:00 Room 315

Antonio Alejandro Valido

Universidad de Las Palmas de Gran Canaria, Spain

Abstract:

We study stochastic resonance in a bistable active model driven by periodic forcing, time-delayed feedback, and both white and colored noise. Using a probability-density approach, linear response theory, and numerical simulations, we analyze the appearance of stochastic resonance. In the small-delay regime, we derive analytical expressions for the stationary probability density, escape rates, and spectral amplification by combining a perturbative treatment of the delayed dynamics with a WKB-like approximation. Our results show that white and colored noise play competing roles: white noise tends to wash out memory effects, whereas colored noise introduces persistence that can reshape barrier crossing and resonance. Time delay also strongly modulates the dynamics by altering the effective stability of the bistable states and the noise-activated transition rates. Numerical simulations of the stochastic delay equations confirm the analytical predictions and reveal a non-monotonic dependence of the resonance on noise strength, delay, and noise correlation time. These results clarify how memory and non-equilibrium fluctuations jointly control bistable stochastic dynamics.

Escaping dynamics of relativistic protons in the Earth's magnetosphere

Schedule: July 9 14:30-15:00 Room 315

Juan C Vallejo

Universidad Rey Juan Carlos, Spain

Abstract:

In this talk, we present the dynamical behavior of charged particles under the influence of the Earth's magnetic field. This work focuses on the motion of the protons in the relativistic regime, analysing the topology of invariant spatial regions in two magnetic field models, namely, the dipolar and Luhmann tail configurations. We compute the distributions of escape and residence times, the exit basins, and the fractal dimensions of their boundaries, as well as a scaling law between the coefficient of the decay law and the energy of the protons. We also present a robust symplectic numerical scheme which is suitable for modeling trajectories where nonlinear effects and the presence of strong sensitivity to initial conditions are present.

Special Session 138 : Differential Equations and Applications to Biology

Organizer(s): Hao Kang , Ran Zhang , Xue Ren

Introduction: The proposed session aims to bring together leading researchers in differential equations, dynamical systems, and mathematical biology to share and discuss their current work and contributions in these interconnected fields. The focus will be on the complex dynamics of biological phenomena, explored through a variety of tools including, but not limited to, differential equations, dynamical systems, machine learning, and artificial intelligence. The talks will highlight new mathematical challenges and biological insights arising from recent research, and are intended to foster discussion and collaboration across diverse areas of expertise.

A Periodic Reaction-Diffusion-Advection SIS Epidemic Model with a Saturated Incidence Function

Schedule: July 8 17:00-17:30 Room 738

Xiaodan Chen

Heilongjiang University, Peoples Rep of China

Co-Author(s): Xiaodan Chen, Renhao Cui, Xiao-Qiang Zhao

Abstract:

In this talk, we consider a reaction-diffusion-advection SIS epidemic model with a saturated incidence function in a spatio-temporally heterogeneous environment. We introduce the basic reproduction number and establish the threshold dynamics of disease transmission based on this value. For the special case of equal diffusion rates, we prove the global attractivity of both the disease-free and endemic periodic solutions. Furthermore, we explore the asymptotic properties of $\mathcal{R}_0$ in relation to dispersal rates, advection, and total population size, while investigating the influence of the period parameter on the limiting profiles of $\mathcal{R}_0$. Finally, we determine the spatial distribution of the disease when the diffusion rate of the infected population is sufficiently small. Our findings suggest that restricting the movement of infected individuals remains a highly effective strategy for disease elimination.

Spreading speed for a time-periodic vector-borne disease system on a growing domain

Schedule: July 8 8:00-8:30 Room 738

Arnaud Ducrot

Universite Le Havre Normandie, France

Abstract:

This paper is concerned with the study of the asymptotic speed of spread for a time-periodic vector-borne disease system posed on the whole space for the host population and on a time varying domain for the vector population. We firstly examine the spreading properties of a time-periodic Fisher-KPP equation posed on a growing domain by constructing appropriate sub- and super-solutions. Then, using the basic reproduction number of the corresponding kinetic system, we describe the long time behavior of the system. In particular when this basic reproduction number is larger than one, we prove that the epidemic is endemic and we derive some estimates for the spreading speed of the invasion of the disease. Finally, numerical simulations are carried out to illustrate our theoretical results.

Slowly oscillating periodic solutions in a nonlinear Volterra equation with non-symmetric feedback

Schedule: July 8 14:00-14:30 Room 738

Quentin GRIETTE

LMAH, University of Le Havre Normandy, France

Co-Author(s): Franco Herrera

Abstract:

In this work we study a nonlinear Volterra equation with non-symmetric feedback that arises as a particular case of the Gurtin-MacCamy model in population dynamics. We are particularly interested in the existence of slowly oscillating periodic solutions when the trivial stationary state is unstable. Here the absence of symmetry of the nonlinearity prevents the use of many traditional strategies to obtain a priori estimates on the solution. Without a precise knowledge of the period of the solution, we manage to prove the forward invariance of a carefully constructed set of initial data whose properties imply the slowly oscillating character of all continuations. We prove the existence of periodic solutions by constructing a homeomorphism between our set and a convex subset of a different Banach space, thereby showing that it possesses the fixed-point property. Finally, in a singular limit of a parameter, we show that this periodic solution converges to the solution of a well-known discrete difference equation. We conclude the paper with some numerical simulations to illustrate the existence of the periodic orbit as well as the singular limit behavior.

The 1978 English boarding school influenza outbreak: where the classic SEIR model fails

Schedule: July 8 8:30-9:00 Room 738

Daihai He

The Hong Kong Polytechnic University, Hong Kong

Abstract:

Previous work has failed to fit classic SEIR epidemic models satisfactorily to the prevalence data of the famous English boarding school 1978 influenza A/H1N1 outbreak during the children's pandemic. It is still an open question whether a biologically plausible model can fit the prevalence time series and the attack rate correctly. To construct the final model, we first used an intentionally very flexible and overfitted discrete-time epidemiologic model to learn the epidemiological features from the data. The final model was a susceptible (S) - exposed (E) - infectious (I) - confined-to-bed (B) - convalescent (C) - recovered (R) model with time delay (constant residence time) in E and I-compartments and multi-stage (Erlang-distributed residence time) in B and C compartments. We simultaneously fitted the reported B and C prevalence curves as well as the attack rate (proportion of children infected during the outbreak). The non-exponential residence times were crucial for good fits. The estimates of the generation time and the basic reproductive number ([Formula: see text]) were biologically reasonable. A simplified discrete-time model was built and fitted using the Bayesian procedure. Our work not only provided an answer to the open question, but also demonstrated an approach to constructive model generation.

Stochastic theory of gene expression and gene regulation

Schedule: July 8 13:30-14:00 Room 738

Chen Jia

Beijing Computational Science Research Center, Peoples Rep of China

Abstract:

Gene regulatory networks in cells are prototypical examples of complex systems, characterized by highly nonlinear and stochastic, multilevel dynamical interactions. Gaining a deep understanding of the stochastic dynamics and thermodynamic principles governing gene regulatory networks not only helps elucidate the intrinsic mechanisms underlying cell fate decisions and the onset and progression of diseases, but also provides new theoretical paradigms for the study of complex systems. This line of research has become one of the forefront interdisciplinary areas internationally, bridging mathematics, physics, biology, chemistry, data science, and intelligent science. In this talk, I will present our recent research progress in this area, with the hope of stimulating further discussion and inspiring new ideas.

Invariant sets under semiflows via a Lie--Trotter product formula for semilinear evolution equations

Schedule: July 8 14:30-15:00 Room 738

Kamal Khalil

LMAH, University of Le Havre Normandie, FR-CNRS-3335, ISCN, Le Havre 76600, France., France

Co-Author(s): Arnaud Ducrot & Ousmane Seydi

Abstract:

Using a Lie--Trotter product formula for local semiflows, we derive sufficient conditions for the invariance of closed convex sets for a class of semilinear parabolic evolution equations in Banach spaces. As an application, we study a coupled diffusion--advection--reaction system and provide concrete assumptions on the initial data ensuring the invariance of prescribed convex regions. In particular, the obtained criteria guarantee positivity and uniform bounds for solutions within this class.

Hopf bifurcation in a time-delayed multi-group SIR epidemic model for behavior change

Schedule: July 8 9:30-10:00 Room 738

Toshikazu Kuniya

The University of Osaka, Japan

Abstract:

In this study, we construct a time-delayed multi-group SIR epidemic model to consider the effect of behavior change. We derive the basic reproduction number $\mathcal{R}_0$ and show that the disease-free equilibrium is globally asymptotically stable if $\mathcal{R}_0 < 1$, whereas an endemic equilibrium exists if $\mathcal{R}_0 > 1$. For a special two-group case with urban and non-urban areas, we obtain sufficient conditions for a Hopf bifurcation which destabilizes the endemic equilibrium and causes a stable limit cycle. By performing the sensitivity analysis, we obtain biological insights that the size of $\mathcal{R}_0$ and the gap of populations, contact rates and sensitivity of behavior change between urban and non-urban areas can play important roles in the occurrence of the Hopf bifurcation.

Dynamics of Consumer Resource Systems

Schedule: July 8 15:00-15:30 Room 738

Rui Li

Shenzhen Technology University, Peoples Rep of China

Co-Author(s): Rui Li

Abstract:

Consumer--resource models provide a framework for describing interacting populations mediated by shared resources and have been widely used to study the dynamics of complex biological systems. In this work, we examine consumer--resource systems from a dynamical perspective. Starting from simple model settings, we extend the analysis to broader regimes and investigate how structural constraints shape system behavior. Alongside the theoretical analysis, we discuss how these models connect to concrete biological contexts, including ecological and microbial systems. This combination of analytical results and applications provides a unified perspective on consumer--resource dynamics and offers insight into the mechanisms underlying complex biological processes.

Exploring the evolution of maturation time via strong competition model with stage structure

Schedule: July 8 15:30-16:00 Room 738

Yifei Li

Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Jian Fang, Ming Xu

Abstract:

In evolutionary and ecological sciences, describing the adaptive dynamics of species affected by the phenotype of maturation time is challenging. In this talk, I will introduce a stage-structured two-species competition model in a discrete environment. When competition leads to long-term bistable dynamics, we obtain the existence of pulsating waves of the population by appealing to monotone dynamical system theories. Furthermore, we numerically explore the relationship between the outcome of competition, characterised by the spreading direction of bistable pulsating waves, and the maturation time of species. When the maturation time has an inverse relationship with the competitiveness of the mature population, there may exist an optimal maturation time suggesting an evolutionarily stable strategy (ESS).

Propagation dynamics of non-cooperative systems and applications to delayed equations

Schedule: July 8 9:00-9:30 Room 738

Guo Lin

Lanzhou University, Peoples Rep of China

Abstract:

In this talk, we first study the propagation dynamics of the following system
$$\begin{cases} \frac{\partial S(x,t)}{\partial t} = d \frac{\partial^2 S(x,t)}{\partial x^2} + f(N(x,t)) - \mu S(x,t) - \beta S(x,t)I(x,t), \\ \frac{\partial I(x,t)}{\partial t} = d \frac{\partial^2 I(x,t)}{\partial x^2} + \beta S(x,t)I(x,t) - (\mu + \gamma)I(x,t) + \delta R(x,t), \\ \frac{\partial R(x,t)}{\partial t} = d \frac{\partial^2 R(x,t)}{\partial x^2} + \gamma I(x,t) - (\mu + \delta)R(x,t), \end{cases}$$
 in which $x \in \mathbb{R}, t > 0$, $N(x,t) = S(x,t) + I(x,t) + R(x,t)$, and all parameters are positive. We investigate the spreading speeds and traveling waves if N has a wave form. Then the idea is utilized to study the propagation dynamics of the following delayed equation

$$\frac{\partial u(x,t)}{\partial t} = \frac{\partial^2 u(x,t)}{\partial x^2} + u(x,t)F(x+ct, u(x,t), (J * u)(x,t)), \quad x \in \mathbb{R}, t > 0.$$

Dynamics of a coupled nonlocal PDE-ODE system with spatial memory: well-posedness, stability, and bifurcation analysis

Schedule: July 8 16:30-17:00 Room 738

Di Liu

Nankai University, Peoples Rep of China

Co-Author(s): Yuriy Salmaniw, Junping Shi, Hao Wang

Abstract:

Nonlocal aggregation-diffusion models coupled with spatial maps provide a framework to capture cognitive and memory-driven effects in animal movement and population dynamics. In this study, we investigate a one-dimensional reaction-diffusion-aggregation system in which population dynamics are coupled with a dynamically evolving map that modulates movement via nonlocal interactions. We first establish the well-posedness of the coupled PDE-ODE system, and then conduct linear stability analysis to identify critical aggregation parameters. A rigorous bifurcation analysis is performed to characterize steady-state behavior near critical thresholds, including the type of bifurcation and the stability of emerging branches. Our results reveal several key biological insights. The spatial map acts as attractive or repulsive depending on the balance between excitation and adaptation effects. In the absence of growth, only single-peak aggregation occurs, indicating that intraspecific competition is essential for multi-peak pattern formation. Moreover, subcritical bifurcations can induce abrupt shifts in population levels, suggesting tipping-point dynamics under moderate parameter changes.

Special Session 139 : Recent advances in modeling and simulation of interfacial dynamics

Organizer(s): Zhen Zhang , Shixin Xu , Yu-Hau Tseng

Introduction: Interfacial dynamics holds a pivotal position as a cross-disciplinary bridge, linking computational fluid mechanics, material sciences, and related fields. Its significance lies in addressing complex phenomena that transcend single-discipline boundaries, such as multiphase flow, fluid-structure interaction, and phase-field behaviors. Practically, it underpins critical applications in energy development (e.g., oil-gas transportation), environmental governance (e.g., pollutant diffusion), and advanced manufacturing (e.g., composite material fabrication), directly responding to pressing industrial and societal needs. Academically, it tackles core bottlenecks like numerical stability in interface capturing and efficiency in multi-scale model coupling, with breakthroughs here driving paradigm shifts in modeling and simulation methodologies. The purpose of this special session is to foster focused exchanges on the modeling and numerical methods of interfacial dynamics, making it indispensable for advancing both fundamental research and real-world problem-solving.

How does Tspan4 shape migrasomes?

Schedule: July 7 15:30-16:00 Room 642

Zhenlin Guo

Beijing Computational Science Research Center, Peoples Rep of China

Co-Author(s): Zhenlin Guo

Abstract:

Migrasomes are membrane-bound organelles whose mechanics remain poorly understood. Here, we develop a phase-field model to reveal how Tspan4 regulates migrasome behavior via membrane tension redistribution. We show that growth-induced membrane stretching generates tension gradients and stiffness heterogeneity, driving vertical elongation and a strong correlation between geometry and stiffness. By varying Tspan4 expression, we demonstrate that increased Tspan4 enhances bending rigidity and accelerates tension redistribution, stabilizing migrasomes, whereas Tspan4 depletion leads to central tension accumulation and higher rupture susceptibility. These findings identify membrane tension redistribution as a key mechanism linking Tspan4 expression to migrasome mechanics and stability

Geometric local parameterization for solving Hele-Shaw problems with surface tension

Schedule: July 7 14:30-15:00 Room 642

Wenrui Hao

Penn State University, USA

Abstract:

We present a computational framework for solving the two-dimensional Hele Shaw free boundary problem with surface tension using a mesh free point cloud representation of the moving interface. By avoiding global parameterization, the method naturally accommodates complex and evolving geometries. Our approach leverages Generalized Moving Least Squares to construct local geometric charts on the boundary, enabling accurate approximation of geometric quantities such as curvature directly from scattered points. This local structure is used to discretize the boundary integral formulation of the problem, with singular integrals evaluated through analytical expressions to maintain high accuracy. We provide a convergence analysis establishing consistency and stability of the spatial discretization, with error bounds depending on point cloud density, boundary smoothness, and quadrature order. Numerical experiments confirm spatial convergence and demonstrate robust evolution of complex initial interfaces toward circular equilibrium under surface tension.

Heterogeneous simulations for interfacial magnetization dynamics

Schedule: July 7 15:00-15:30 Room 642

Guanghui Hu

University of Macau, Macau

Co-Author(s): Zheng Zekai

Abstract:

The precise capture of interfacial magnetization dynamics, such as domain wall motion and skyrmion evolution at heterostructure interfaces, remains a formidable challenge in computational spintronics due to the high non-linearity and multiscale nature of the governing equations. This talk presents recent progress in developing a high-performance simulation framework for the Landau-Lifshitz-Gilbert equation. We focus on a synergistic approach that integrates high-order structure-preserving numerical schemes with GPU-accelerated heterogeneous computing. The numerical framework consists of a structure preserving temporal discretization and finite element spatial discretization. A treecode algorithm is designed and implemented in GPU to significantly accelerate the simulations. Numerical experiments demonstrate that our framework provides competitive performance and flexibility on handling complex geometry of the domain, for resolving the dynamics of the domain wall, as well as skyrmion structures.

TINNs: Time-Induced Neural Networks for Solving Time-Dependent PDEs

Schedule: July 7 14:00-14:30 Room 642

Ming-Chih Lai

National Yang Ming Chiao Tung University, Taiwan

Co-Author(s): Chen-Yang Dai, Che-Chia Chang, Te-Sheng Lin, Chieh-Hsin Lai

Abstract:

Physics-informed neural networks (PINNs) solve time-dependent partial differential equations (PDEs) by learning a mesh-free, differentiable solution that can be evaluated anywhere in space and time. However, standard space-time PINNs take time as an input but reuse a single network with shared weights across all times, forcing the same features to represent markedly different dynamics. This coupling degrades accuracy and can destabilize training when enforcing PDE, boundary, and initial constraints jointly. We propose Time-Induced Neural Networks (TINNs), a novel architecture that parameterizes the network weights as a learned function of time, allowing the effective spatial representation to evolve over time while maintaining shared structure. The resulting formulation naturally yields a nonlinear least-squares problem, which we optimize efficiently using a Levenberg-Marquardt method. Experiments on various time-dependent PDEs show up to $4\times$ improved accuracy and $10\times$ faster convergence compared to PINNs and strong baselines.

A structure-preserving finite element scheme and its error analysis for a diffuse-interface tumor growth model

Schedule: July 7 13:30-14:00 Room 642

Ping Lin

University of Dundee, Scotland

Abstract:

We will discuss a diffuse-interface (phase-field) model for tumor growth that takes into account nutrient consumption and chemotaxis. For this tumor growth model described by a nonlinear system consisting of a Cahn-Hilliard-type equation coupled with a reaction-diffusion equation, we constructed an efficient scheme based on the idea of the scalar auxiliary variable (SAV), which we show are not only decoupled and easy to implement, but also have the properties of mass conservation and unconditional energy stability. Furthermore, we derive rigorous error estimates for the fully discrete finite element scheme. Several numerical examples are presented to validate the accuracy, mass conservation and energy dissipation of the proposed scheme, and to illustrate complex biological phenomena, including the aggregation of multiple tumors of varying shapes and chemotaxis-driven growth patterns. The talk is based on two joint papers with Z Wang and J Yang, and with A Soenjaya and T Tran.

Mathematical modeling, analysis and numerical investigation of ion active transport with free boundaries

Schedule: July 7 18:00-18:30 Room 642

Yuzhe Qin

Shanxi University, Peoples Rep of China

Co-Author(s): Huaxiong Huang, Zilong Song, Shixin Xu

Abstract:

We study a diffusive interface model for ion active transport through free boundaries. By an energy-variation approach, we derive a phase-field system that couples the order parameter, species concentrations, electrostatic potential, and incompressible flow, and establish an energy dissipation law. A sharp interface limit analysis is carried out to connect the diffuse-interface model with the corresponding free-boundary formulation. Based on the thermodynamically consistent structure, we design an unconditionally energy stable scheme. Numerical tests in one and two dimensions validate the model and demonstrate key features of active transport, with additional comparisons to results reported in the literature. The proposed framework provides a consistent modeling and simulation tool for ion transport with restricted diffusion across membranes.

Moving contact lines on elastic sheets

Schedule: July 7 17:00-17:30 Room 642

Weiqing Ren

National University of Singapore, Singapore

Abstract:

We investigate the motion of a thin liquid drop on highly bendable elastic sheets. Under the lubrication approximation, we derive a coupled system of fourth-order partial differential equations, together with appropriate boundary and contact line conditions, to describe the evolution of both the fluid interface and the elastic sheet. Using matched asymptotic analysis in the limit of small slip length, we extend the classical Cox-Voinov relation to incorporate the effects of substrate elasticity. The extended relation is validated through numerical simulations. One key implication is that, compared with a rigid substrate, a soft substrate retards drop spreading but enhances receding dynamics.

Macroscopic modeling and simulations for thin film with moving contact lines

Schedule: July 7 17:30-18:00 Room 642

Xianmin XU

Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Si Xiao

Abstract:

Thin liquid films with contact lines are common in nature and in engineering applications. The existence of free boundaries and singularities poses significant challenges for both modeling and computation. In this talk, we present a unified framework for the derivation and numerical approximation of a fourth-order thin film equation with mesoscopic dynamic boundary conditions. The reduced model is systematically derived using the Onsager variational principle in conjunction with lubrication theory, yielding a thermodynamically consistent formulation that accounts for capillarity, gravity, and external force. To solve the resulting free boundary problem, we develop adaptive moving mesh methods based on a discrete Onsager variational principle, including a stabilized semi-implicit scheme to improve computational efficiency. Numerical results confirm the optimal convergence of the proposed methods and accurately capture key wetting behaviors, including contact angle hysteresis on rough substrates. This work offers a robust framework for simulating thin film flows with complex geometries.

Multilevel Schwarz Methods for the Coupled Stokes-Darcy Problem

Schedule: July 7 18:30-19:00 Room 642

Haicheng Zhang

Heidelberg University, Germany

Abstract:

We present a monolithic multigrid solver for a strongly mass-conservative mixed finite element discretization of the coupled Stokes-Darcy problem. An overlapping Schwarz smoother is employed, and different treatments of boundary degrees of freedom are compared. In particular, we investigate the effect of velocity and pressure boundary conditions in the Darcy subdomain, as well as the inclusion of boundary unknowns in the vertex patches. Numerical results show that the convergence behavior, especially for the pressure, strongly depends on the smoother design. With a consistent treatment of boundary degrees of freedom, the proposed method is robust and requires less than 10 iterations for high-order discretizations.

Special Session 140 : Recent advances in wavelet analysis, PDEs and dynamical systems – part III

Organizer(s): Emanuel Guariglia

Introduction: This session is a follow-up of the SS134 - AIMS ABU DHABI 2024. We focus our attention on recent interconnections between wavelet analysis, PDEs and dynamical systems – including pure analysis and applications. More precisely, we intend to deal with the interconnection between these three research fields. Particular emphasis will be given to all the applications in fractal geometry and related areas. Our goal is to bring together scholars working in PDEs, nonlinear analysis and dynamical systems, in order to report the newest progress, exchange ideas and forge new cooperation.. The following is a non-exhaustive list of topics to be discussed in this session. • Wavelet methods for PDEs • Self-similar solutions • Analysis on fractals • Analytical methods for PDEs • Fractal-wavelet characterization of dynamical systems • Multiresolutional algorithms for operator equations • Hamiltonian systems, Lyapunov functions and stability • Dynamical systems and fractal sets • Variational methods

An Accurate Numerical Model for Solving Elliptic-Type PDEs Directly

Schedule: July 10 11:30-12:00 Room 445

Emmanuel O Adeyefa

Federal university Oye-Ekiti, Nigeria

Co-Author(s): E. O. OMOLE

Abstract:

This paper presents a new accurate elliptic partial differential equation solver (AEPDES). The AEPDES has its nodes within the eight-step interval and targets elliptic partial differential equations on the two-dimensional domain. A collocation approach is adopted to develop this method, while a Hermite polynomial is employed as the basis function. The interpolation points are carefully selected at the two desired points, and at all the suitably preferred grid and off-grid points. By uniting the resulting equations and evaluating them at selected points, the classical AEPDES is obtained. Investigating the numerical properties of the AEPDES, it was confirmed that the AEPDES is zero-stable and consistent. The accuracy and efficiency of the AEPDES were established by solving varying elliptic partial differential equations

ANALYSIS AND MODELLING OF FASHION TRENDS

Schedule: July 10 9:30-10:00 Room 445

Hyeong-Ohk Bae

Ajou University, Korea

Co-Author(s): Hyeong-Ohk Bae

Abstract:

We suggest a system of differential equations that models the formulation and evolution of a trend cycle through the consideration of underlying dynamics between the trend participants. Our model captures the five stages of a trend cycle, namely, the onset, rise, peak, decline, and obsolescence. It also provides a unified mathematical criterion/condition to characterize the fad, fashion and classic. Such a model is based on an elasticity in non-Newtonian fluid. We prove that the solution of our model can capture various trend cycles. Numerical simulations are provided to show the expressive power of our model.

Non local dynamical boundary condition on irregular structures

Schedule: July 9 8:00-8:30 Room 445

Raffaella Capitanelli

Sapienza University ROMA, Italy

Abstract:

Recently non-local boundary value problems have been investigated together with the associated probabilistic representation in terms of sticky Brownian motions (see [CD], [D1], [D2]). In the present talk, I present some results on non-local dynamic boundary conditions on irregular structures like snowflake type fractals. [CD] Raffaella Capitanelli, Mirko D'Ovidio. On the Laplace equation with non-local dynamical boundary conditions. *Evolution Equations and Control Theory*, 2026, 16: 1-15. [D1] M. D'Ovidio, Fractional Boundary Value Problems, *Fract. Calc. Appl. Anal.*, 1 25, (2022), 29-59. [D2] M. D'Ovidio, Fractional Boundary Value Problems and Elastic Sticky Brownian Motions, *Fract. Calc. Appl. Anal.*, 27 (2024) 2162-2202.

Fixed-point theorems for semilinear operator equations and applications

Schedule: July 9 13:30-14:00 Room 445

Wenying Feng

Trent University, Canada

Abstract:

We study extensions of basic fixed-point theorems to semilinear operator equations. Using an approach that moves from concrete algorithms to abstract operator formulations, we establish a class of generalized existence and multiplicity results for fixed points on order intervals in partially ordered Banach spaces. The results are obtained under conditions that relax or replace the usual compactness and cone assumptions and are designed to accommodate semilinear operators arising in applications. In particular, the theorems recover and extend classical results and provide verifiable conditions for a broader class of nonlinear operators.

Prime subsets, chaoticity and IFSs

Schedule: July 9 8:30-9:00 Room 445

Emanuel Guariglia

Kean University, Italy

Abstract:

In this talk, we deal with the link between prime subsets, fractal sets and IFSs. More precisely, numerical simulations suggest that different prime subsets (e.g., Chen primes, Ramanujan primes) exhibit fractal-like behavior. Therefore we introduce an IFS to describe prime subsets. Finally, we show that our results has an application in dynamical systems, cryptography and signal processing.

Ill-Posed Boundary Value Problems for Multidimensional PDEs of Keldysh Type

Schedule: July 9 9:00-9:30 Room 445

Tsvetan Hristov

Sofia University "St. Kliment Ohridski", Bulgaria

Abstract:

From the classical works of Keldysh and Fichera, it is well known that BVPs for multidimensional linear second-order equations with a non-negative characteristic form are well understood in the sense that boundary conditions should not be imposed on the whole boundary. In this talk analogous statements of multidimensional BVPs for weakly hyperbolic equations of Keldysh type are studied. These equations are considered in a domain bonded by two characteristic surfaces and a ball in the hyperplane of the parabolic degeneration. A data is prescribed only on a part of the characteristic boundary, while the parabolic part of the boundary is free of data and the normal derivative of the solution can have singularity on it. In the frame of the classical solvability these problems are not Fredholm, since they have infinite-dimensional co-kernels. Alternatively, a notion of a generalized solution with possible singularity is given. Results on the existence and uniqueness of such solution are obtained under special condition on the lower-order terms. Further, orthogonality conditions on the smooth right-hand side functions are presented, which are necessary and sufficient for the existence of generalized solutions with fixed order of singularity.

Nonlinear instability of rolls in the 2-dimensional generalized Swift-Hohenberg equation

Schedule: July 9 14:00-14:30 Room 445

Soyeun Jung

Kongju National University, Korea

Abstract:

In this talk, we rigorously establish the nonlinear instability of roll solutions to the two-dimensional generalized Swift-Hohenberg equation. Our analysis is based on spectral information near the maximally unstable Bloch mode, combined with precise semigroup estimates. We construct a certain class of small initial perturbations that grow in time and cause the solution to deviate from the underlying roll solution within a finite time. This result provides a clear transition from spectral to nonlinear instability in a genuinely two-dimensional setting, where the Bloch parameter ranges over an unbounded domain.

Inverse Problems for Nonlinear Epidemiological Models: Parameters Identifications and Validation of SEIRS-type Models

Schedule: July 10 9:00-9:30 Room 445

Veneta Koleva

Sofia University St. Kliment Ohridski, Bulgaria

Co-Author(s): Veneta Koleva

Abstract:

Inverse epidemiological problems involving nonlinear ordinary differential equations are generally ill-posed. For this reason, it is necessary to determine parameters, or combinations of parameters, that can be uniquely identified from available real-world data. This talk addresses inverse problems for a time-dependent SEIRS model incorporating vaccination, hospitalization, and vital dynamics. First, a mathematical analysis is performed to establish essential biological and analytical properties of the model, including non-negativity, boundedness, and the existence and uniqueness of solutions. The core contribution of this work lies in the formulation and solution of time-discrete inverse problems aimed at identifying unknown, time-dependent model parameters from reported epidemiological data. This inverse methodology enables reliable calibration of the model and provides insight into the time evolution of the epidemic. Numerical experiments using actual COVID-19 data from the USA, Italy, and Bulgaria demonstrate the robustness and practical applicability of the proposed approach. Furthermore, the model is used to compute key epidemiological indicators, such as time-dependent basic and effective reproduction numbers. Provided that suitable epidemiological data are available, the model and its associated simulation tools can be applied to data from any country, making the framework broadly applicable for epidemic analysis and decision support.

Trajectorial version of the W_h -gradient flow for nonlinear Fokker-Planck equations

Schedule: July 9 16:30-17:00 Room 445

Zhenxin Liu

Dalian University of Technology, Peoples Rep of China

Co-Author(s): Xuewei Wang

Abstract:

In this talk, we will introduce a trajectorial approach to the gradient flow of nonlinear Fokker-Planck equations. We first give the definitions of the generalized entropy and the modified Wasserstein metric W_h , which is adapted to the nonlinear setting. Then we establish the trajectorial version of the relative entropy dissipation identity by McKean-Vlasov SDEs. Averaging the energy dissipation of trajectories yields the free energy dissipation of nonlinear Fokker - Planck equations. Furthermore, leveraging properties of the tangent space of $(\mathcal{P}_2(\mathbb{R}^d), W_h)$, we derive the W_h -gradient flow. As an illustrative example, we analyze the Fermi-Dirac-Fokker-Planck equation. We conclude with two questions motivated by numerical observations.

Optimal Regularity for the Scalar and N Membranes Alt-Phillips Free Boundary Problem

Schedule: July 10 11:00-11:30 Room 445

Kunyi (Mark) Ma

Columbia University, USA

Abstract:

It is known that the classical Obstacle and Alt-Caffarelli Problems can be regarded as two endpoint cases for the family of free boundary problems, known as the Alt-Phillips Problem. Their minimizers are non-negative, subharmonic, and solves an elliptic-type equation in the positive set with an a priori unknown positive-zero set interface, which we call the 'Free Boundary'. In proof of the Optimal Regularity, the classical approaches involve showing the optimal growth rate near the boundary, then combining with the interior equation to gain full regularity. In this work, we discuss a novel dichotomy argument initiated by De Silva - Savin. The key idea is to say, for the size of the minimizer u sufficiently large at unit scale, either the size of u shrinks by $1/2$, or u is sufficiently close to its harmonic replacement, as one goes to the next scale. We also discuss a generalization to the vectorial N -Membrane Alt-Phillips Free Boundary Problem, and study how the same argument transfers. In particular, we point out the key difference between the Alt-Phillips with parameter in $(0, 1)$, and the endpoint cases.

From bilinear forms to nonlinear PDEs: Soliton theory

Schedule: July 9 14:30-15:00 Room 445

Wen-Xiu Ma

University of South Florida, USA

Abstract:

Solitons offer fundamental insight into the dynamics of nonlinear systems and arise in a wide range of applications across physics and mathematics. The Hirota bilinear method provides a powerful framework for analyzing such solutions in integrable PDEs, enabling the systematic construction of multi-soliton solutions by transforming nonlinear PDEs into bilinear form. In this talk, we examine criteria for the existence of N -soliton solutions, illustrated through examples in both $(1+1)$ - and $(2+1)$ -dimensional settings. We also explore generalized bilinear equations and their corresponding soliton solutions.

ON SOME THERMOELASTIC SHEAR BRESSE SYSTEMS

Schedule: July 10 10:30-11:00 Room 445

Salim Messaoudi

University of Sharjah, United Arab Emirates

Abstract:

In this talk we present three one-dimensional linear thermoelastic shear Bresse systems, where the heat effect is given by Fourier's law. First, for one problem, we discuss the well-posedness, using the semigroup approach and the stability, using the multiplier method. Secondly, we shed some light on the others.

Deterministic and stochastic analysis of eco-epidemic models, focusing on fear, refuge, and selective predation dynamics

Schedule: July 9 17:00-17:30 Room 445

Samarees Pal

University of Kalyani, India

Co-Author(s): Sasanka Shekhar Maity

Abstract:

In this investigation, we delve into the dynamics of an eco-epidemic model, considering the intertwined influences of fear, refuge-seeking behavior, and alternative food sources for predators with selective predation. We extend our model to incorporate the impact of fluctuating environmental noise on system dynamics. The deterministic model undergoes thorough scrutiny to ensure the positivity and boundedness of solutions, with equilibria derived and their stability properties meticulously examined. Furthermore, we explore the potential for Hopf bifurcation within the system dynamics. In the stochastic counterpart, we prioritize discussions on the existence of a globally positive solution. Through simulations, we unveil the stabilizing effect of the fear factor on susceptible prey reproduction, juxtaposed against the destabilizing roles of prey refuge behavior and disease prevalence intensity. Notably, when disease prevalence intensity is too low, the infection can be eradicated from the eco-system. Our deterministic analysis reveals a complex interplay of factors: the system destabilizes initially but then stabilizes as the fear factor suppressing disease prevalence intensifies, or as predators exhibit a stronger preference for infected prey over susceptible ones, or as predators are provided with more alternative food sources.

Asymptotically Self-Similar global Solutions for the Inhomogenous Nonlinear Schrödinger Equation

Schedule: July 9 17:30-18:00 Room 445

Slim TAYACHI

University of Tunis El Manar, Tunisia

Co-Author(s): L. Aloui, N. Ben Mosbah and S. Tayachi

Abstract:

We study the nonlinear inhomogeneous Schrödinger equation $i\partial_t u + \Delta u = \mu|x|^{-b}|u|^\alpha u$ and prove global existence, including self-similar solutions, for small initial data in suitable Besov spaces. The results extend to equations with general potentials. We then describe the large-time behavior: depending on the decay of the initial data, solutions are either asymptotic to self-similar solutions of the nonlinear equation or governed by the linear flow. In particular, for sufficiently decaying potentials, solutions exhibit asymptotic behavior described by self-similar solutions of the linear Schrödinger equation.

Hyperbolic Cahn-Hilliard Equations with Dynamic Boundary Conditions

Schedule: July 9 15:00-15:30 Room 445

Sema Yayla

Hacettepe University, Turkey

Abstract:

In this talk, we study the hyperbolic Cahn-Hilliard equation endowed with dynamic boundary conditions, derived from principles of mass conservation and energy minimization. We analyze the well-posedness and long-time behavior of the model in the two-dimensional setting, employing the framework of global attractors. This work is part of the TUBITAK 3501 project (Grant No. 123F453), titled Investigation of the Long-Time Behavior of Hyperbolic Cahn-Hilliard Equations, and is funded by The Scientific and Technological Research Council of Türkiye (TUBITAK).

On Parabolic Equations with Singular Coefficients and Initial-Boundary Data

Schedule: July 9 9:30-10:00 Room 445

Alibek Yeskermessuly

Altynsarin University, Kazakhstan

Co-Author(s): Michael Ruzhansky

Abstract:

We study a linear second-order parabolic equation in divergence form with drift and potential terms on a bounded domain with initial data and non-homogeneous Dirichlet boundary conditions. The analysis focuses on situations where the coefficients and data may exhibit singular or distributional behavior. First, assuming bounded measurable diffusion, drift, and potential coefficients, we prove existence, uniqueness, and a priori estimates for weak solutions in the natural energy space associated with the divergence-form operator. The proof is based on energy methods and Galerkin approximations. We then extend the framework to allow singular coefficients and data, including distributional potentials, source terms, initial values, and boundary conditions. In this setting we introduce a notion of very weak solutions obtained via regularization of the coefficients and data. Existence and uniqueness of such solutions are established under suitable ellipticity and positivity assumptions. Finally, we prove a consistency result showing that, in the regular case, representatives of the very weak solution converge in the energy space to the classical weak solution.

An Efficient Laguerre Minimum Action Method for Quasi-Potential and Transition Path Computing

Schedule: July 9 15:30-16:00 Room 445

Haijun Yu

Academy of Mathematics and Systems Science, Peoples Rep of China

Co-Author(s): Shenghe Huang, Yishuang Yue and Haijun Yu

Abstract:

Minimum action methods provide a powerful framework for analyzing rare transitions in stochastic dynamical systems, but their practical performance is often limited by time truncation and parameter sensitivity in infinite-horizon problems. We propose an efficient Laguerre spectral minimum action method for computing quasi-potentials associated with fixed points of dynamical systems. Based on the large deviation framework, the method computes minimum action transition paths by formulating the problem on a semi-infinite time interval and discretizing the temporal direction using Laguerre functions. An appropriate time-scaling strategy is incorporated to enhance accuracy and convergence of the Laguerre spectral approximation. To efficiently handle nonlinear terms, we develop an improved procedure for evaluating Laguerre functions at Gauss--Radau quadrature points, which enables stable double-precision computations with a large number of Laguerre modes. Numerical analysis and experiments are presented to illustrate the accuracy and efficiency of the proposed method.

Special Session 141 : New trends and methods for differential problems

Organizer(s): Simone Creo , Ida De Bonis

Introduction: This Special Session is devoted to the presentation of new developments in various fields of Mathematical Analysis, ranging from ODEs to PDEs to functional inequalities. We are interested both in theoretical and practical results about linear and nonlinear problems. We especially wish to highlight new methods for attacking such problems, with the aim of inspiring new scientific relationships between researchers who deal with these topics, even with different approaches.

Multiscale analysis in composite materials with rough imperfect interfaces

Schedule: July 9 17:00-17:30 Room 638

Micol Amar

Department of Basic and Applied Sciences for Engineering - Sapienza University of Rome, Italy

Co-Author(s): Daniele Andreucci, Claudia Timofte

Abstract:

In the last years, the improvements of industrial techniques has permitted to obtain more efficient materials constructed by assembling different constituents, whose physical properties are definitely superior than the ones of the single components. However, this bonding does not give rise in general to perfect contacts between the different components, so that discontinuities in the involved physical fields can appear. Also the study of boundary value problems in composites with rough boundaries or interfaces is a topic that has recently attracted a significant interest due to their applications in many areas of natural or engineering sciences, such as fluid mechanics, materials science, biology, etc. In this talk, we present some recent results concerning the study of problems where imperfect contact conditions couple with oscillating interfaces. More precisely, we consider a stationary heat diffusion problem in a two-component material, which exhibits an imperfect contact across an oscillating interface separating the two constituents. At the microscopic scale, it is mathematically described by an elliptic boundary value problem stated in each of two connected components. The heat potential is continuous across the interface, while its flux jumps according to suitable prescribed conditions, which lead to different macroscopic models, obtained through an asymptotic analysis.

The motion of a liquid drop

Schedule: July 9 9:00-9:30 Room 638

Domenico Angelo Angelo

Università degli studi di Napoli Federico II, Italy

Abstract:

In this talk we summarize some new results obtained in the last few years regarding the evolution of a liquid drop. The main focus will be towards the existence of global solutions to the free boundary Euler equation describing the problem.

Nonlocal semilinear differential equations with superlinear growth

Schedule: July 9 15:00-15:30 Room 638

Irene Benedetti

Department of Mathematics and Computer Science, University of Perugia, Italy

Abstract:

This talk is devoted to the study of existence results for semilinear parabolic partial differential equations with nonlocal initial conditions and superlinear growth. The class of nonlocal conditions considered includes, as special cases, multipoint Cauchy problems, weighted mean value conditions, and periodic problems. The analysis is carried out by applying a Leray-Schauder continuation principle, reformulating the problem as an ordinary differential equation in an abstract Banach space setting. In this framework, Lebesgue spaces provide the natural setting in which parabolic equations can be rewritten as ordinary differential equations. A major difficulty arises from the presence of superlinear nonlinearities, since the associated Nemytskii operator is not, in general, continuous on Lebesgue spaces unless sublinear growth conditions are satisfied, as highlighted by Vainberg's theorem. This issue is addressed by exploiting the compactness and regularizing properties of the semigroup generated by the linear part of the equation, together with the construction of a suitable approximation scheme. These techniques allow us to establish existence results beyond the classical sublinear framework.

Solutions and algebraic properties of nonlinear equations of soliton type

Schedule: July 9 18:30-19:00 Room 638

Sandra Carillo

University LA SAPIENZA, Italy

Co-Author(s): Sandra Carillo

Abstract:

Soliton equations play a central role from an applied perspective because they admit solutions whose shape remains unchanged during propagation and whose amplitude is conserved over time. Such equations frequently appear in applied mathematics, with applications spanning fluid dynamics, nonlinear optics, acoustics, theoretical physics and, more recently, biophysics. In the present work we consider solutions of the matrix modified Korteweg-de Vries (mKdV) equation. These solutions can properly be termed soliton solutions, since they manifest the characteristic behavior of solitons. In particular, two-soliton solutions of the $d \times d$ matrix mKdV equation are constructed as in [1]. This work builds on a general explicit formula for N -soliton solutions in the infinite-dimensional (operator) case, as studied in [2], while the explicit finite-dimensional (matrix) case is treated in detail in [5]. Additionally, invariance properties of third-order KdV-type equations in non-commutative (matrix) contexts have been investigated more recently in [6]. Solutions of matrix mKdV equation are presented which can be termed soliton solutions since they exhibit the typical behaviour of solitons. Specifically, two-soliton solutions of the $d \times d$ -matrix modified Korteweg de-Vries equation are obtained in [1]. An explicit formula in the matrix case is studied in [3] while invariance properties of third order KdV-type equations are investigated in [6]. An overview on recent and perspective result is in [7]. [1] S. Carillo, C. Schiebold, Construction of soliton solutions of the matrix Korteweg-de Vries and modified Korteweg-de Vries equations, in *Advances in Nonlinear Dynamics. NODYCON Conference Proceedings Series*. Springer, Cham, ISBN 978-3-030-81169-3, W. Lacarbonara, et al. Ed.s, 481--491 (2022). doi: 10.1007/978-3-030-81170-9_42, arXiv: 2011.12677. [2] S.~Carillo and C.~Schiebold, Matrix Korteweg-de Vries and modified Korteweg-de Vries hierarchies: Non-commutative soliton solutions, *J. Math. Phys.* 52 (2011), 053507. doi: 10.1063/1.3576185 27-37. [3] S. Carillo, M. Lo Schiavo, C. Schiebold, N -soliton matrix mKdV solutions: Some Special Solutions Revisited, *Studies in Applied Mathematics*, 2025; 154: e70061. doi: doi.org/10.1111/sapm.70061. [4] S.~Carillo and C.~Schiebold, On the asymptotical description of soliton solutions to the matrix modified Korteweg-de Vries equation, submitted 2023. *Advances in Nonlinear Dynamics - Proc.s of the Third International Nonlinear Dynamics Conference (NODYCON 2023)*, Vol. 3, W. Lacarbonara, Ed. 565--575 (2024). doi: 10.1007/978-3-031-50635-2_43. [5]. S. Carillo, M. Lo Schiavo, C. Schiebold, Matrix solitons solutions of the modified Korteweg-de Vries equation, *NODYCON 2019 Springer Proceedings*, B. Balachandran, J. Ma, W. Lacarbonara, G. Quaranta, J. Machado, G. Stepan, Ed.s, (2020), 75-83. doi: 10.1007/978-3-030-34713-0_8. [6] S. Carillo, C. Schiebold, Soliton equations: admitted solutions and invariances via Bäcklund transformations, *Open Commun. Nonlinear Math. Phys., Episciences*, ISSN: 2802-9356, S.I. 1, 1--11 (2024). doi: 10.46298/ocnmp.12497. [7] S. Carillo, C. Schiebold, F. Zullo, Nonlinear evolution equations of soliton type: old and new results, *Proceedings, MDPI*, 2025; 123(1):9, 2025. doi: 10.3390/proceedings2025123009.

Uniqueness results for fractional Dirichlet problems in symmetric domains

Schedule: July 9 13:30-14:00 Room 638

Isabella Ianni

Sapienza University, Italy

Co-Author(s): De Marchis, Dieb, Saldana

Abstract:

We discuss recent uniqueness and nondegeneracy results obtained for non-negative solutions of some fractional semilinear problems in bounded domains with Dirichlet exterior condition. In particular we can consider least energy solutions in balls or in more general symmetric domains, for problems with power nonlinearities. The symmetry properties of the solutions of the associated linearized equation are also investigated.

Numerical analysis of a coupled system of parabolic equations with nonlinear and nonlocal drift

Schedule: July 9 15:30-16:00 Room 638

Nicklas Javergard

Karlstad University, Sweden

Co-Author(s): Nicklas Javergard, Rainey Lyons, Adrian Muntean

Abstract:

We study the formation and evolution of complex morphologies that arise in systems of equations governed by nonlinear and nonlocal interactions. Starting from the continuum formulation, which is derived from a particular hydrodynamic limit of the lattice-based Blume-Capel model with Kawasaki dynamics, we analyze a class of partial differential equations that capture the interplay between diffusion and interaction-driven transport in a ternary mixture. We propose a semi-discrete finite volume scheme to approximate the unique weak solution of the system. We prove that our scheme is well-posed and converge to the wanted solution. Furthermore, we show that the scheme is stable with respect to a parameter in the drift term.

A priori bounds for planar elliptic equations and systems

Schedule: July 9 14:30-15:00 Room 638

Gabriele Mancini

University of Bari Aldo Moro, Italy

Co-Author(s): Luca Battaglia, Laura Baldelli, Giulio Romani, Pierre-Damien Thizy

Abstract:

I will discuss some recent results concerning uniform a priori bounds for positive solutions of elliptic equations and semilinear Hamiltonian elliptic systems involving exponential-type non-linearities in dimension two. These topics are presented in joint works in collaboration with Laura Baldelli (Karlsruhe Institute of Technology), Luca Battaglia (Università degli Studi Roma Tre), Giulio Romani (Università degli Studi di Udine) and Pierre-Damien Thizy (Université Claude Bernard Lyon 1). In the case of systems, we consider a broad class of coupled nonlinearities with asymptotic critical behaviour in the sense of Brezis-Merle. The approach we follow is based on a blow-up analysis combined with Liouville-type theorems and integral estimates. As a consequence of our a priori estimates, we prove the existence of a positive solution by means of fixed point index theory.

Dirichlet problem on perturbed conical domains via converging generalized power series

Schedule: July 9 16:30-17:00 Room 638

Paolo Musolino

Università degli Studi di Padova, Italy

Co-Author(s): Martin Costabel, Matteo Dalla Riva, Monique Dauge

Abstract:

We consider the Poisson equation with homogeneous Dirichlet conditions in a family of domains in $\mathbb{R}^n$ indexed by a small parameter ε . The domains depend on ε only within a ball of radius proportional to ε and, as ε tends to zero, they converge in a self-similar way to a domain with a conical boundary singularity. We construct an expansion of the solution as a series of real positive powers of ε , and prove that it is not just an asymptotic expansion as $\varepsilon \rightarrow 0$, but that, for small values of ε , it converges normally in the Sobolev space H^1 . A planar version of such problem has been previously investigated by the authors with the so called Functional Analytic Approach, based on integral representations obtained through layer potentials. Here, instead, we choose a different technique that allows us to relax all regularity assumptions. We forgo boundary layer potentials and instead exploit expansions in terms of eigenfunctions of the Laplace-Beltrami operator on the intersection of the cone with the unit sphere. The basis for our analysis is a two-scale cross-cutoff ansatz for the solution that has similarities with the Maz'ya-Nazarov-Plamenevskij construction of a multiscale system for the asymptotic expansion of solutions of boundary value problems on domains singularly perturbed near singular points of the boundary.

Asymptotic behavior of Finsler p -Laplace eigenvalues

Schedule: July 9 17:30-18:00 Room 638

Gianpaolo Piscitelli

Universita' degli studi di Napoli Parthenope, Italy

Co-Author(s): R. Barbato, F. Della Pietra, and G. Piscitelli

Abstract:

The aim of this talk is to present three convergence results connecting Finsler p -Laplace eigenvalue problems with Cheeger-type constants in the limit as $p \rightarrow 1$. After recalling the known asymptotic results for the first Dirichlet eigenvalue, we first address the convergence of the first Robin eigenvalue, using Gamma-convergence to identify the limit as a Finsler Cheeger-type problem in BV. We then turn to the second eigenvalue and eigenfunctions, whose limiting behavior is related to the second Finsler Cheeger constant. Finally, we study a twisted eigenvalue problem and its convergence to the corresponding twisted Finsler Cheeger constant under a volume constraint. The talk is based on the following works: [1] R. Barbato, F. Della Pietra, G. Piscitelli, On the first Robin eigenvalue of the Finsler p -Laplace operator as $p \rightarrow 1$, J. Math. Anal. Appl. 540, 128660 (2024), 1-25. [2] G. Piscitelli, On the second anisotropic Cheeger constant and related questions, J. Convex Anal. 33.1&2 (2026), 303-324.

Uniqueness for Neumann problems for nonlinear elliptic equations with lower order terms

Schedule: July 9 14:00-14:30 Room 638

Maria Rosaria MR Posteraro

University of Naples Federico II, Italy

Co-Author(s): M.F.Betta, O. Guibé, A. Mercaldo

Abstract:

We prove uniqueness results for weak solutions to a class of Neumann problems, whose prototype is $\begin{cases} \Delta u = \lambda (1 + |u|^{p-2})u - \operatorname{div}((1 + |\nabla u|^{p-2}) \nabla u) & \text{in } \Omega \\ c(x) (1 + |u|^{p-2})u = f & \text{on } \partial\Omega \end{cases}$ where Ω is a bounded open subset of $\mathbb{R}^N$ ($N \geq 2$) with Lipschitz boundary, p is a real number $\frac{2N}{N+1} < p$

Homogenization of reaction-diffusion equation with large nonlinear drift

Schedule: July 9 18:00-18:30 Room 638

Vishnu Raveendran

University of Bonn, Germany

Co-Author(s): I. de Bonis, E.N.M Cirillo, and A. Muntean.

Abstract:

We discuss the periodic homogenization of a reaction-diffusion problem with nonlinear drift posed in an unbounded perforated domain. The nonlinear problem is associated with the hydrodynamic limit of an asymmetric simple exclusion process governing a population of interacting particles crossing a domain with obstacles. We are interested in deriving the upscaled model equations and the corresponding effective coefficients for the case when the microscopic dynamics are linked to a particular choice of characteristic length and time scales that lead to a fast nonlinear drift.

Spectral clusters

Schedule: July 9 8:00-8:30 Room 638

Giorgio Saracco

Universita' di Ferrara, Italy

Co-Author(s): Giorgio Stefani

Abstract:

Given any open, bounded set Ω , we consider suitable combinations, via a reference function Φ , of the first p -eigenvalue of the Dirichlet Laplacian of partitions of Ω . We give two different formulations of the problem, one geometrical and one functional. We prove relations among the two formulations, existence and regularity of optimal partitions, convergence, and stability with respect to p and to Φ . Based on a joint work with G. Stefani (Padova).

On a new concept of controllability of second-order semilinear differential equations in Banach spaces

Schedule: July 9 9:30-10:00 Room 638

Valentina Taddei

University of Modena and Reggio Emilia, Italy

Co-Author(s): Martina Pavla\v{c}kov'a

Abstract:

In this talk, we investigate the controllability of second-order problems in Banach spaces, when the nonlinear term also depends on the first derivative. In the existing literature, the most commonly adopted notion of exact controllability for second-order equations ensures only that the state function attains the desired target value, while neglecting the behavior of its derivative at the final time, thereby violating the concept of controllability. The primary aim of this work is to introduce a new definition of controllability for second-order problems in Banach spaces, which simultaneously accounts for both the solution and its derivative at the final time, through a single control function. We then establish sufficient conditions guaranteeing this controllability. Our approach yields results under easily verifiable and non-restrictive assumptions on the cosine family generated by the associated linear operator, as well as on the nonlinear term, without requiring any compactness conditions. Finally, we illustrate the applicability of our results by considering a system governed by the one-dimensional Klein-Gordon equation.

Boundary regularity at characteristic points in the Heisenberg group

Schedule: July 9 8:30-9:00 Room 638

Giulio Tralli

University of Ferrara, Italy

Abstract:

In this talk we focus on the boundary regularity of the solutions to Poisson-type problems with homogeneous boundary datum. We discuss the geometric case of the Heisenberg group, where we fix the subLaplacian as the relevant (degenerate-elliptic) operator and the characteristic half-space as the (scale-invariant) domain. We show an intrinsic second order expansion at the only characteristic point of the boundary when the source term belongs to an appropriate weighted L^∞ space. The technique we adopt is inspired by Caffarelli approach to Krylov's boundary $C^{1,\alpha}$ -estimate for uniformly elliptic operators in nondivergence form. This is a joint work with F. Abedin.

Special Session 142 : Recent developments for PDE constrained shape and topological optimization and their applications

Organizer(s): Chiu-Yen Kao , Braxton Osting

Introduction: Problems in PDE constrained shape and topological optimization have many applications in fluid dynamics, thermal conductivity, waveguides, mechanical vibrations, population dynamics, and image processing. Such problems require efficient, accurate, and robust numerical methods for solving the governing partial differential equations and iterative optimization approaches to find the optimal geometry. This minisymposium aims to bring together mathematicians and scientists interested in this interdisciplinary area to share recent results and exchange ideas.

Numerical optimization of Stokes eigenvalues

Schedule: July 6 16:30-17:00 Room 640

Pedro Antunes

University of Lisbon, Portugal

Co-Author(s): Nuno Martins

Abstract:

We study a volume-constrained shape optimization problem for the eigenvalues of the Stokes operator in two and three dimensions, aiming to identify domains that minimize individual eigenvalues. While the ball is known to satisfy optimality conditions in two dimensions (Henrot, Mazari-Fouquer and Privat), this is no longer the case in three dimensions. We propose a numerical framework based on the Method of Fundamental Solutions (MFS) to approximate the solutions of the Stokes eigenvalue problem. The validity of this approach is supported by density results established in this work. The optimization is carried out using a gradient-type method. To address the difficulties associated with eigenvalue multiplicities, we adopt a smoothing strategy based on lower-order eigenvalues. Instead of computing the shape gradient of the target eigenvalue directly, we consider the gradients of a set of preceding eigenvalues. This approach allows us to define a smooth objective functional, in contrast with the standard formulation, which is typically non-differentiable in a neighborhood of the optimal shape due to eigenvalue multiplicities. The effectiveness of the method is demonstrated through numerical experiments, which highlight qualitative differences between optimal shapes in two and three dimensions. This is a joint work with Nuno Martins (Universidade Nova de Lisboa)

Numerical Exploration of Blaschke--Santaló Diagrams Using Neural Networks

Schedule: July 6 17:00-17:30 Room 640

Eloi Martinet

Institute for Mathematics, JMU Wuerzburg, Germany

Abstract:

We are interested in the use of neural networks for shape optimization and their application in the exploration of shape functionals, also called Blaschke--Santaló diagrams. In a first part, we show how a certain neural network architecture allows one to represent convex bodies in any dimension without constraints. By leveraging the automatic differentiation capabilities of PyTorch, we demonstrate that this representation can be applied effortlessly to shape optimization problems. In a second part, in collaboration with Ilias Ftouhi, we show how to take advantage of this parametrization to provide a faithful numerical description of various Blaschke--Santaló diagrams, by representing each convex body as a repulsive electric charge in the diagram.

Graph and domain partitioning based upon escape time optimization

Schedule: July 6 17:30-18:00 Room 640

Jeremy L Marzuola

University of North Carolina, USA

Co-Author(s): Zach Boyd, Nico Fraiman, Peter Mucha, Braxton Osting, Arunima Bhattacharya, Matthias Kurzke, Dan Weser

Abstract:

We provide a rearrangement based algorithm for fast detection of subgraphs of k vertices with long escape times for directed or undirected networks. Complementing other notions of densest subgraphs and graph cuts, our method is based on the mean hitting time required for a random walker to leave a designated set and hit the complement. We provide a new relaxation of this notion of hitting time on a given subgraph and use that relaxation to construct a fast subgraph detection algorithm and a generalization to K -partitioning schemes. Using a modification of the subgraph detector on each component, we propose a graph partitioner that identifies regions where random walks live for comparably large times. Importantly, our method implicitly respects the directed nature of the data for directed graphs while also being applicable to undirected graphs. We apply the partitioning method for community detection to a large class of model and real-world data sets. We also discuss existence and boundary regularity for a related algorithm on domains/manifolds.

Convergence of thresholding schemes

Schedule: July 6 13:30-14:00 Room 640

Idriss Mazari-Fouquer

CEREMADE, Paris Dauphine University PSL, France

Co-Author(s): A. Chambolle, Y. Privat

Abstract:

We will give an overview of recent progress in the study of quantitative inequalities for optimal control problems. In particular, we will show how they can be used to obtain convergence results for thresholding schemes, which are of great importance in the simulation of optimal control problems. This is a joint work with A. Chambolle and Y. Privat.

Accelerated Rearrangement Methods for Two-Phase PDE-Constrained Optimisation

Schedule: July 6 14:00-14:30 Room 640

Seyyed Abbas Mohammadi

University of Dundee; Wits University, Scotland

Abstract:

We study a class of PDE-constrained optimisation problems in which the control is restricted to take two values under a global constraint, leading naturally to a topological optimisation framework. Such problems arise in applications including material design, population dynamics, and spectral optimisation. From an analytical perspective, optimal solutions exhibit a bang--bang structure and can be characterised using rearrangement theory and symmetrisation techniques, providing insight into the geometry of optimal configurations, although explicit solutions are typically available only in special cases. On the computational side, rearrangement methods offer an efficient iterative approach based on thresholding of state or adjoint variables. These methods are known to converge and, in certain settings, achieve linear convergence rates; however, their performance may still be limited in practice. Motivated by acceleration techniques in optimisation, we introduce an accelerated rearrangement method (ARM) for two-phase problems. The method incorporates momentum-type updates through extrapolation of Fréchet derivatives while preserving admissibility of the control. Numerical results demonstrate significantly improved convergence compared to classical rearrangement schemes.

Steklov-Wentzell Eigenvalues of Nearly Spherical Domains

Schedule: July 6 15:00-15:30 Room 640

Chee Han Tan

National Sun Yat-Sen University, Taiwan

Co-Author(s): Robert Viator

Abstract:

We consider the Steklov-Wentzell eigenproblem on nearly spherical domains in $\mathbb{R}^{d+1}$ with $d + 1 \geq 3$, where we include the Laplace-Beltrami operator in the usual Steklov boundary condition. Treating such domains as perturbations of the unit ball, we derive the first-order asymptotic expansion for the Laplace-Beltrami operator and combine this with our previous results from the Steklov eigenproblem to compute the first-order asymptotic expansion for a family of scaled-invariant Steklov-Wentzell eigenvalues. By decomposing the first-order perturbation matrix using the addition theorem for spherical harmonics, we prove that the ball is substationary for an infinite list of scale-invariant Steklov-Wentzell eigenvalues. We extend the analysis to show that the ball is stationary for certain functionals of Steklov-Wentzell eigenvalues and obtain, as a special case, related local isoperimetric results for functionals of Steklov eigenvalues.

Extremal Steklov-Neumann Eigenvalues

Schedule: July 6 15:30-16:00 Room 640

Robert Viator

Denison University, USA

Co-Author(s): Chiu-Yen Kao, Braxton Osting, Chee Han Tan

Abstract:

We consider the Steklov-Neumann eigenproblem on an open bounded planar domain Ω with smooth connected boundary Γ . We pose the extremal eigenvalue problems of minimizing/maximizing the k -th non-trivial Steklov-Neumann eigenvalue among boundary partitions into Steklov subdomains Γ_S and Neumann subdomains Γ_N of prescribed measure. We formulate a relaxation of these EEPs in terms of $L^\infty(\Gamma)$ densities rather than partitions of Γ , and establish existence and optimality conditions for these relaxed EEPs. We also establish a homogenization result that allows solutions of the relaxed EEPs to infer properties of the original EEPs. Given time, we will explore numerical evidence of symmetries of minimizing arrangements of Γ_S and Γ_N for the k -th Steklov-Neumann eigenvalue of the disk.

Efficient iterative-convolution thresholding methods for interface related optimization problems

Schedule: July 6 14:30-15:00 Room 640

Dong Wang

The Chinese University of Hong Kong, Shenzhen & Shenzhen International Center for Industrial and Applied Mathematics,
Peoples Rep of China

Co-Author(s): Dong Wang

Abstract:

Interface related problems have a lot of applications in fluid dynamics, material science, image processing, shape and topology optimization, and so on. In this talk, we propose to use indicator functions to implicitly represent the interface, introduce a concave approximation to the energy/objective functional, and derive an unconditionally stable iterative method for interface related problems. We will introduce a topology optimization problem as one example for optimization cases. Some other applications including image segmentation, configuration of foam bubbles, optimal partition will also be presented.

Special Session 143 : Nonlinear dynamics for kinetic, fluids and mathematical physics

Organizer(s): Hyeong-Ohk Bae , Jongmin Han , Jeongho Kim

Introduction: Nonlinear systems are found in many areas like physics, biology, engineering, economics, and social sciences. They show us how complex nature can be. In this session, we plan to explore the complex behaviors of particles, fluid flow and many other physical objects that are controlled by nonlinear events. We hope this meeting will lead to new research ideas and help us find new ways to solve the complex problems of nonlinear dynamics in particles, fluids and many other physical or social objects.

Decay Rates of Solutions to Some Dissipative Equations

Schedule: July 8 17:00-17:30 Room 316

Hantaek Bae

UNIST, Korea

Abstract:

In this talk, we demonstrate how to derive temporal decay rates for weak solutions to the incompressible Navier-Stokes equations. We establish these rates by employing the Fourier splitting method with initial data in spaces of negative regularity. We also discuss applications of our approach to the surface quasi-geostrophic (SQG) equations and magnetohydrodynamics (MHD).

Existence for steady-state $p(u)$ -Laplacian problems related with Image Processing

Schedule: July 9 15:30-16:00 Room 316

Hyeong-Ohk Bae

Ajou University, Korea

Abstract:

We construct weak solutions to the $p(u)$ -Laplace equation $-\nabla \cdot (|\nabla u|^{p(u)-2} \nabla u) = f$ in Ω . These problems arise in adaptive image denoising, where the diffusion depends on the solution itself. The main challenge stems from the variable exponent, which prevents the use of fixed Sobolev spaces. We overcome this difficulty by employing a sophisticated version of the Lipschitz truncation method, combined with a localized Minty argument. This approach enables us to prove the existence of weak solutions under minimal regularity assumptions, without requiring the restriction $p(u) > d$, where d is the space dimension. Our result applies to a broader class of nonlinear diffusion equations and contributes to the analysis of models where the equation's behavior may depend on the solution itself.

Analysis of Voigt-type fluid models: existence, regularity and long-time behavior

Schedule: July 9 9:30-10:00 Room 316

Hermenegildo B de Oliveira

University of the Algarve, Portugal

Abstract:

In this talk we present several recent results on the mathematical analysis of Voigt-type regularizations of fluid flow models. These models extend the classical Navier-Stokes framework by incorporating relaxation or viscoelastic effects, leading to improved analytical properties while preserving the main features of the fluid dynamics models. We study different formulations of these systems, including generalized power-law models, flows with non-homogeneous density, and models allowing the presence of vacuum regions. For the associated nonlinear initial-boundary value problems, we establish results on the existence, uniqueness, and regularity of weak and strong solutions under suitable assumptions on the nonlinear exponents and the spatial dimension. We also investigate qualitative properties of the solutions, including long-time behavior and decay rates in the presence of source or sink terms, as well as smoothing and decay mechanisms for the linearized barotropic Navier-Stokes-Voigt system. These results contribute to a unified mathematical framework for the analysis of Voigt-regularized fluid models.

Convergence and asymptotics for multi-component Ginzburg-Landau equations

Schedule: July 9 18:00-18:30 Room 316

Jongmin Han

Kyung Hee University, Korea

Abstract:

Let (u_ε) be a family of solutions of the Ginzburg--Landau equation with boundary condition $u_\varepsilon = g$ on $\partial\Omega$ and of degree zero. According to [Bethuel-Brezis-H\"{e}lein, 1993], the H^1 convergence of u_ε is a key ingredient of uniform convergence. In this talk, we give an equivalent condition for H^1 convergence. Furthermore, we generalize it to multi-component Ginzburg-Landau equations. We also talk about the recent progress of asymptotics of minimizers for the multi-component Ginzburg-Landau energy.

Modified scattering for the Vlasov-Riesz system with long-range interactions

Schedule: July 9 15:00-15:30 Room 316

Younghun Hong

Chung-Ang university, Korea

Co-Author(s): Younghun Hong; Stephen Pankavich

Abstract:

We study the long-time asymptotic behavior of small-data solutions to the three-dimensional Vlasov--Riesz system with the inverse power-law potential $\lambda|x|^{-\alpha}$ in the strictly long-range regime ($0 < \alpha < 1$). By introducing finite- and infinite-time modified wave operators for the characteristic flows, we describe the asymptotic dynamics via convergence to an effective profile along a suitably modified reference flow, and establish modified scattering of solutions. Our proof relies mainly on ODE techniques for the characteristic flows, while also using PDE methods for weighted $W^{1,\infty}$ -bounds. Compared with the earlier result \cite{HuangKwon}, our Lagrangian approach extends modified scattering to the broader regime $\frac{1}{2}$

Optimal Convergence Estimate of the Limit from Inverse Power Potential to Hard Sphere Boltzmann Equation

Schedule: July 8 16:30-17:00 Room 316

Jin Woo Jang

POSTECH (Pohang University of Science and Technology), Korea

Co-Author(s): Zheng-Nan Hu, Jin Woo Jang, Zheng-An Yao, Yu-Long Zhou

Abstract:

The inverse power potential $U(r) = r^{-1/s}$, $0 < s < 1$, generates the Boltzmann kernel $B^s = |v - v_*|^{1-4s} b_s(\theta)$ with an angular singularity as $\theta \rightarrow 0$. Jang et al. [Jang2023-df] proved the limit $B^s \rightarrow \frac{1}{4}|v - v_*|$ as $s \rightarrow 0$, as well as weak convergence of solutions based on this kernel convergence. In this talk I further introduce recent establishment of the following sharp quantitative estimate:

$$|b_s(\theta) - \frac{1}{4}| \leq C s \theta^{-2-2s}.$$

In particular, this sharp estimate yields the \emph{optimal} $O(s)$ convergence rate for solutions of the homogeneous Boltzmann equation with large initial data in suitable Sobolev spaces; i.e., for any $t \in [0, T]$, we have

$$f^s(t) = f^0(t) + O(s),$$

quantified by the L_k^1 norm for $k \geq 2$. This is a joint work with Zheng-Nan Hu, Zheng-An Yao, and Yu-Long Zhou.

Maximal L^p Regularity for Nonhomogeneous Neumann Problems and Its Applications to Fluid Dynamics

Schedule: July 9 14:30-15:00 Room 316

Bum Ja Jin

Mokpo National University, Korea

Abstract:

This talk presents the maximal L^p regularity for the heat equation subject to nonhomogeneous Neumann boundary conditions and a divergence-form external source. While maximal regularity is well-established for homogeneous cases, nonhomogeneous boundary data often introduce technical complexities, particularly in fluid dynamics models. Our work establishes a robust maximal L^p estimate for the generalized solution to this problem. As a key application, we demonstrate how this estimate improves the weak solution framework for the compressible Navier-Stokes equations with inflow-outflow boundary conditions. Specifically, we show that our regularity results allow for the removal of the artificial terms previously required in approximate systems (e.g., [Chang, Jin, and Novotny]), thereby providing a more physical and streamlined analysis of the Navier-Stokes equations under nonhomogeneous boundary settings.

Stability of compressible flows with boundary in one space dimension

Schedule: July 9 9:00-9:30 Room 316

Moon-Jin Kang

Korea Advanced Institute of Science and Technology, Korea

Abstract:

The stability of entropy solutions to the compressible Euler equations on a halfline with prescribed boundary conditions (such as inflow; outflow; impermeable problems) remains a largely open problem. For the Euler system as hyperbolic equations, the dimension of admissible boundary set depends on the characteristic speeds, making it highly nontrivial to determine under which boundary set the stability can be guaranteed. Even the fundamental questions on how a single Riemann shock approaching the boundary behaves and whether such a shock is stable remains open. In this talk, I will present a recent progress concerning these problems.

On wellposedness of alpha-SQG equations in the half-plane

Schedule: July 9 16:30-17:00 Room 316

Junha Kim

Ajou University, Korea

Co-Author(s): In-Jee Jeong, Yao Yao

Abstract:

We investigate the wellposedness of alpha-SQG equations in the half-plane, where $\alpha=0$ and $\alpha=1$ correspond to the 2D Euler and SQG equations respectively. We prove local wellposedness and illposedness in anisotropic weighted Holder spaces. This talk is based on joint work with In-Jee Jeong and Yao Yao.

On the Role of Energy Stability in Numerical Methods for Incompressible Fluid Equations

Schedule: July 9 8:00-8:30 Room 316

Byungjoon Lee

The Catholic University of Korea, Korea

Co-Author(s): Chohong Min, Jeongho Kim, Dongnam Ko

Abstract:

Energy stability plays a fundamental role in the design of reliable numerical methods for incompressible flow problems. In this talk, we present a unified framework for constructing energy-stable schemes across a range of challenging settings, including variable-density Navier-Stokes flows, high-order time discretizations, two-phase flows with surface tension, and fluid-solid interaction. Our approach is based on discrete energy laws that guarantee non-increasing total mechanical energy at the fully discrete level. Key ingredients include reformulations of the governing equations using suitable state variables, structure-preserving discretizations that mimic integration-by-parts on staggered grids, and both implicit and explicit time integration strategies with provable stability properties. In particular, we develop schemes that are conditionally or unconditionally energy stable while achieving improved accuracy, including second-order convergence. We further extend these ideas to adaptive grid frameworks for complex geometries and multiscale interactions, where consistent projections across grid interfaces preserve stability. Numerical experiments demonstrate that the proposed methods achieve robustness and efficiency across diverse incompressible flow regimes, highlighting the central role of energy stability in modern computational fluid dynamics.

L^∞ theory with stretched exponential weight for the Boltzmann equation

Schedule: July 9 8:30-9:00 Room 316

DONGHYUN LEE

POSTECH, Korea

Co-Author(s): Sungbin Park and Jongin Kim

Abstract:

Even in the spatially homogeneous case, any Maxwellian upper bound for the Boltzmann solution must be characterized by an exceptionally small decay rate in the velocity variable. This motivates us to study the Boltzmann equation with a stretched exponential weight, $e^{-\alpha|v|^\kappa}$ for $\kappa < 2$. In this talk, we discuss the well-posedness of the Boltzmann equation in $L_{x,v}^\infty$ within this stretched exponential framework. In particular, we address the large-amplitude problem of the Boltzmann equation and beyond.

Homogeneous solutions to the Einstein--Boltzmann system with a conformal gauge singularity

Schedule: July 8 17:30-18:00 Room 316

Ho Lee

Kyung Hee University, Korea

Co-Author(s): Ernesto Nungesser, John Stalker, Paul Tod

Abstract:

We consider the Einstein--Boltzmann system for massless/massive particles in the Bianchi I spacetime with scattering cross-sections in a certain range of soft potentials. We assume that the spacetime has an initial conformal gauge singularity and show that the initial value problem is well posed with data given at the singularity.

A Theory-guided Weighted L2 Loss for solving the BGK model via Physics-informed Neural Networks

Schedule: July 9 14:00-14:30 Room 316

Myeong-Su Lee

Seoul National University, Korea

Co-Author(s): Gyoungun Ko, Sung-Jun Son, and Seung-Yeon Cho

Abstract:

While Physics-Informed Neural Networks offer a promising framework for partial differential equations, the standard L2 residual loss is insufficient for solving the Bhatnagar-Gross-Krook model of the Boltzmann equation. Specifically, small L2 residuals do not guarantee small errors in macroscopic moments, causing the standard PINN to fail in capturing the true solution. To resolve this, we propose a weighted L2 loss function based on a stability analysis. The stability analysis implies that minimizing this weighted residual strictly controls the distance between the exact and approximate solutions. Finally, numerical experiments shows that employing this theoretical guided PINN loss leads to superior accuracy across various benchmarks compared to the standard PINN approach.

Quantitative hydrodynamic limit of the Chern--Simons--Higgs system

Schedule: July 9 13:30-14:00 Room 316

Bora Moon

Yonsei University, Korea

Co-Author(s): Jeongho Kim

Abstract:

We study the hydrodynamic limit of the Chern--Simons--Higgs system, a relativistic Chern--Simons gauge field model. We introduce a single scaling parameter capturing both the non-relativistic (infinite speed of light) and semi-classical (vanishing Planck constant) regimes. This unified scaling allows us to justify the simultaneous non-relativistic and semi-classical limit, while retaining the nontrivial effect of the Chern--Simons gauge structure. Using a modulated energy method, we establish quantitative convergence rates toward the corresponding compressible Euler--Chern--Simons system as the scaling parameter tends to zero.

On rotating solutions for Euler-Poisson equations

Schedule: July 9 17:30-18:00 Room 316

Jinmyoung Seok

Seoul National University, Korea

Co-Author(s): Juhi Jang

Abstract:

In this talk, I will present some ideas for constructing single and multi-body rotating solutions of Euler-Poisson equations and establishing their nonlinear dynamical stability. The first part will be devoted to foundational theory and key historical developments. In the second part, I will discuss several recent results, including some of my own work.

Homogenization of non-divergence type equation with oscillating coefficients defined on a highly oscillating obstacles.

Schedule: July 9 17:00-17:30 Room 316

Minha Yoo

National Institute for Mathematical Sciences, Korea

Co-Author(s): Sunghoon Kim, Ki-Ahm Lee, Se-Chan Lee

Abstract:

In this talk, we discuss the homogenization of a highly oscillating obstacle problem using the viscosity method. The equation we deal with is a non-divergence type equation with oscillating coefficients. To analyze the behavior of solutions in the obstacle problem, we construct a corrector function, periodic function when the obstacle is given as 1. By utilizing this corrector, we identify the so-called strange term behavior when the size of the domain where the obstacle is defined reaches a critical value. We then modify the corrector for critical size and analyze the solution's behavior when the size of the obstacle is either larger or smaller than the critical value.

Special Session 144 : PDEs and Irregular Interfaces: New Frontiers for Industrial Applications

Organizer(s): Michael Hinz , Maria Rosaria Lancia , Chiara Sargentone

Introduction: Partial differential equations (PDEs) in domains with irregular interfaces are encountered in a wide range of scientific and industrial applications. They play a huge role in composite materials, fluid-structure interaction and multiphase flows, and they arise naturally in civil and biomedical engineering. The geometric complexity of irregular interfaces poses huge challenges for both the rigorous analytical understanding of PDEs in such domains (well-posedness, regularity, etc.) and an efficient numerical approximation (mesh generation, adaptive methods, unfitted discretizations, etc.). The special session aims to bring together leading experts in analytical techniques, computational methods, and applied modeling. Its goal is to foster interaction between these different sub-disciplines and scientific communities, to exchange knowledge and explore synergies, to encourage joint projects and to stimulate new directions of research. Topics of interest include, but are not limited to: interface problems for elliptic and parabolic PDEs, advanced numerical techniques for domains with complicated geometries, quadrature methods with special attention to singularity problems, boundary integral formulations, robust coupling techniques for different physical regimes across interfaces, and inverse problems in irregular domains.

A fast integral equation solver for self-similar and prefractal domains with corners

Schedule: July 10 11:00-11:30 Room 628

Ludvig af Klinteberg

Malardalen University (MDU), Sweden

Co-Author(s): Ludvig af Klinteberg

Abstract:

Boundary integral equation methods are highly efficient tools for solving elliptic boundary value problems on domains with complex geometries. Nonetheless, prefractal and self-similar domains with corners, such as the Koch curve, remain challenging because of corner singularities in the solution. In this talk, we show how state-of-the-art numerical methods can overcome these difficulties, yielding a framework for the efficient solution of discretized boundary value problems that lead to dense linear systems with millions of degrees of freedom. This makes it possible to solve the problem on very fine prefractal approximations and to study the convergence of the resulting numerical solutions in the fractal limit.

On the traces of harmonic functions $H^{1/2}$ and $H^{3/2}$ in Lipschitz domains

Schedule: July 10 9:00-9:30 Room 628

Cherif Amrouche

Universite de Pau et des Pays de l'Adour, France

Co-Author(s): Mohand Moussaoui

Abstract:

In this work, we revisit the following estimate due to Dahlberg \cite{Dahl}. Let x_0 a fixed point in a bounded Lipschitz domain Ω . Then there exists a constant $C > 0$ such that if u is a harmonic function in Ω and vanishes at x_0 , then

$C^{-1}\|u\|_{L^2(\Gamma)} \leq \left(\int_{\Omega} \varrho |\nabla u|^2 \right)^{1/2} \leq C\|u\|_{L^2(\Gamma)}$, where ϱ is the distance to the boundary of Ω . Using Grisvard's work and interpolation theory for subspaces, we complete the solvability of the inhomogeneous Dirichlet problem:

$$(\mathcal{L}_D^0) - \Delta u = f \text{ in } \Omega \text{ and } u = 0 \text{ on } \Gamma,$$

in a framework of fractional Sobolev spaces $H^s(\Omega)$, when Ω is a polygon or a polyhedron domain and $1/2 \leq s \leq 2$. Thanks to these regularity results and an explicit function given by Nečas, we show that the above inequalities cannot be valid in their current form. On the other hand, we identify a functional space which satisfies the embeddings

$H_{00}^{1/2}(\Omega) \hookrightarrow E(\nabla; \Omega) \hookrightarrow H^{1/2}(\Omega)$ and the trace operator γ_0 from $E(\nabla; \Omega)$ into $L^2(\Gamma)$ is well-defined and continuous. This leads to an alternative to the functions $H^{1/2}(\Omega)$, non necessarily harmonic, for having a trace in $L^2(\Gamma)$ and also to a new characterization of $H_{00}^{1/2}(\Omega)$ as the kernel of this operator. However, we show that if the domain Ω is of class $\mathcal{C}^{1,1}$, then the above inequalities are valid.

A Functional Framework for Maxwell's Equations on H^1 -Extension Domains

Schedule: July 10 16:30-17:00 Room 628

Romain CERVERA

Universite Paris Saclay, France

Co-Author(s): Anna Rozanova-Pierrat, Patrick Ciarlet, Alexander Teplyaev

Abstract:

The mathematical analysis of boundary value problems for Maxwell's equations traditionally requires at least a Lipschitz-continuous boundary to properly define trace operators. Building upon the work of Creo, Lancia, Vernole, Hinz, and Teplyaev (2018) regarding fractal boundaries, we address the challenge of formulating electromagnetic problems on highly irregular geometries. Our focus is on the large class of H^1 -extension domains, where classical tools relying on surface measures and standard boundary regularity break down. To overcome this, we propose a boundary measure-free approach that relies entirely on the intrinsic Hilbert structure of the trace space. Within this framework, we construct the notion of normal and tangential trace operators for the spaces $\mathbf{H}(\text{div}, \Omega)$ and $\mathbf{H}(\text{curl}, \Omega)$, providing a rigorous basis for solving electromagnetic boundary value problems in geometries where classical theory is not applicable.

Acoustic impedance scattering on extension domains

Schedule: July 10 15:00-15:30 Room 628

Gabriel CLARET

Paris-Saclay University, France

Co-Author(s): Anna Rozanova-Pierrat

Abstract:

From sonars to medical imaging or even robot vacuum cleaners, acoustic scattering is at the core of numerous applications. In an acoustic scattering problem, an incident acoustic field is scattered by an obstacle in such a way that the total field -- superposition of the incident and scattered ones -- satisfies a given boundary condition. Modelling that problem, a crucial aspect is the geometry of the obstacle, and it is known that irregular shapes such as fractals are most relevant to represent the behaviour of real-life objects. In this talk, we discuss the acoustic scattering problem by an obstacle described by a Sobolev extension domain. Those domains can be smooth, Lipschitz, but also fractal, multi-fractal... That obstacle is endowed with an impedance-type boundary condition, understood with but also without a boundary measure. Relying on tools from potential theory, we study the well-posedness of the impedance scattering problem in both cases, which we restate in terms of boundary equations. As an application of our analysis, we consider the inverse scattering problem consisting in identifying the obstacle and the boundary condition from many scattered plane waves.

Obstacle problems for nonlinear fractional operators in irregular domains

Schedule: July 10 15:30-16:00 Room 628

Simone Creo

Sapienza Universita' di Roma, Italy

Co-Author(s): Salvatore Fragapane

Abstract:

In this talk we study obstacle problems for the regional fractional p -Laplacian in a domain $\Omega \subset \mathbb{R}^2$ having fractal boundary of Koch type. We first prove well-posedness results for the solution of the obstacle problem, as well as two equivalent formulations. Then, we study corresponding approximating obstacle problems in a sequence of domains $\Omega_n \subset \mathbb{R}^2$ having pre-fractal boundary, for $n \in \mathbb{N}$. After proving the well-posedness of the approximating obstacle problems, we perform the asymptotic analysis for both $n \rightarrow +\infty$ and $p \rightarrow +\infty$.

Integral equation methods for ice floes and other surface wave scattering problems

Schedule: July 10 12:00-12:30 Room 628

Tristan Goodwill

University of Chicago, USA

Abstract:

Ocean waves cause large deformations floating ice sheets and ice floes, which can cause icequakes and more generally impact the stability of the cryosphere. These waves are also an example of bulk-surface problems involving complicated boundary conditions, nonlocal effects, and infinite or extended interfaces. In this talk, I present novel integral equation methods and fast solvers for a broad class of surface wave problems. The integral equation is Fredholm second kind and only posed on a compact region of interest. I demonstrate the effectiveness of these methods on a variety of glaciological applications.

A discontinuous Galerkin method on a fractal domain

Schedule: July 10 10:30-11:00 Room 628

David P Hewett

University College London, England

Co-Author(s): Andrea Moiola, Sergio Gomez

Abstract:

When using classical FEM to solve a PDE problem in a domain with a complicated or non-smooth boundary, one typically requires a mesh with a large number of elements in order to accurately capture the boundary geometry. In this talk we present a discontinuous Galerkin (dG) FEM for the solution of PDE problems in a domain with a fractal boundary (the Dirichlet Poisson problem in the Koch snowflake) in which the boundary geometry is captured exactly, by using a mesh comprising elements which themselves have fractal boundary. On such meshes the classical dG normal derivative interface terms cannot be defined in the usual way because inter-element interfaces may not have a well-defined normal vector. We show how this can be addressed by introducing proxies for the normal derivative terms, based on integrals over subsets of the mesh elements. We prove well-posedness of the resulting dG FEM and provide a partial error analysis. We also discuss practical implementation of the method and provide numerical results demonstrating its effectiveness. This is joint work with Sergio Gomez and Andrea Moiola.

High order cubature for iterated function system

Schedule: July 10 14:00-14:30 Room 628

Zo{\''\i}s Moitier

ENSTA, France

Co-Author(s): Patrick Joly, Maryna Kachanovska

Abstract:

The talk is motivated by application to fractal antenna engineering, where antennas with self-similar shapes operate across multiple frequencies. Recent works by Chandler-Wilde, Gibbs, Hewett, Moiola and their co-workers propose boundary integral formulations for solving Helmholtz scattering problems on fractal screens with Dirichlet boundary conditions. These boundary integral equations utilize the Hausdorff measure on fractals instead of the standard Lebesgue's measure. This makes the evaluation of the boundary integral difficult from a numerical viewpoint. To tackle this point, we propose new interpolatory high-order tensor cubature formula on fractals, based on Chebyshev points on an interval. These formulas allow computing integrals of restrictions of regular functions to fractals with a high accuracy. We will discuss the construction of such cubature (in particular computation of the weights) and their properties (asymptotic behavior of weights).

Potential flow solver for ship hydrodynamics problems with fully nonlinear free surface boundary conditions

Schedule: July 10 11:30-12:00 Room 628

Andrea Mola

IMT School for Advanced Studies Lucca, Italy

Co-Author(s): Andrea Mola

Abstract:

This contribution will present a mathematical model for the simulation of the flow past a ship sailing in calm or wavy water. The fluid dynamic model is based on the potential flow theory and is governed by the Laplace equation, here complemented by fully nonlinear boundary conditions on the water free surface and non penetration boundary conditions on the ship hull. The spatial discretization of the Laplace equation is carried out by means of the Boundary Element Method (BEM), while the discretization of the time dependent fully nonlinear free surface boundary conditions is based on the Finite Element Method (FEM). Such a combined FEM-BEM spatial discretization strategy results in a Differential Algebraic Equations (DAE) system, that is time integrated via implicit Backward Difference Formula (BDF) method with variable degree and time step. The numerical solver is implemented in a stand alone C++ program which efficiently leverages on several open source numerical libraries. Validation test cases based on comparison with experimental measurements obtained on industrial benchmark hulls will be presented. In addition, some results on the application on competition rowing boat hulls will be shown and discussed.

Identification of constant coefficients in a model of linear anisotropic subdiffusion

Schedule: July 10 9:30-10:00 Room 628

Gianluca Mola

Sorbonne University Abu Dhabi, Italy

Co-Author(s): Simone Creo, Maria Rosaria Lancia, Andrea Mola and Silvia Romanelli

Abstract:

Let $(H, \langle \cdot, \cdot \rangle)$ be a Hilbert space and $A_i : D(A_i) \rightarrow H$ ($i = 1, \dots, n$) be a family of nonnegative and self-adjoint operators mutually commuting. We study the inverse problem consisting in the identification of the function $u : [0, \infty) \rightarrow H$ and n constants $\lambda_1, \dots, \lambda_n > 0$ that fulfill the initial-value problem

$$\partial_t^\alpha u(t) + \lambda_1 A_1 u(t) + \dots + \lambda_n A_n u(t) = 0, \quad t > 0, \quad u(0) = x,$$

and the additional energy measurements at $t = T$

$$\langle A_1 u(T), u(T) \rangle = \varphi_1, \quad \dots, \quad \langle A_n u(T), u(T) \rangle = \varphi_n.$$

Here, ∂_t^α denotes the Caputo fractional derivative of order $0 < \alpha < 1$, which accounts for models of subdiffusion phenomena. Under suitable assumptions on the initial datum $x \in H$, we shall provide a uniqueness result. Existence is also achieved, assuming that the overdeterminating conditions $\varphi_1, \dots, \varphi_n > 0$ belong to a proper set, which is described in concrete cases by means of numerical simulations for different values of α . Finally, we prove the convergence of the solution $(u, \lambda_1, \dots, \lambda_n)$ as $\alpha \rightarrow 1^-$, thus linking the fractional derivative model with the classic derivative one. Applications to heat conduction and plane elasticity are considered.

On Rumples and Rolls: Efficient Representations for Elastodynamics in Ice Sheets

Schedule: July 10 17:30-18:00 Room 628

Peter Nekrasov

University of Chicago, USA

Co-Author(s): Peter Nekrasov, Jeremy G. Hoskins

Abstract:

Elastic waves are involved in a number of important phenomena, including the bending and flexing of floating ice sheets driven by the ocean. These elastic effects are frequently modeled using a time-harmonic wave equation with zero traction boundary conditions, which correspond to a free or unconstrained surface. In this talk, we introduce a novel approach for handling coupled hydro-elastic waves that reduce the problem to a Fredholm second kind integral equation on the boundary. These techniques are applied to ongoing fieldwork around the rumple zones of the McMurdo Ice Shelf in order to better understand wave localization and propagation in the polar regions.

The Drude-Born-Fedorov system on anisotropic fractal porous media

Schedule: July 10 14:30-15:00 Room 628

Eric Stachura

Kennesaw State University, USA

Co-Author(s): Ioannis Stratis

Abstract:

In this talk, I will discuss a mathematical framework for wave propagation in anisotropic fractal porous media. These materials are fractal structures that could have different dimensions in each direction and appear, for instance, in the modeling of composite structures with fractal type microstructures. I will discuss the vector framework to study electromagnetic wave propagation and apply it to the special case of the Drude-Born-Fedorov system--a particular model of an electromagnetically bi-anisotropic medium which incorporates chirality. This is joint work with I. G. Stratis (National and Kapodistrian University of Athens).

The radiation condition for Helmholtz equations above (locally perturbed) periodic surfaces

Schedule: July 10 17:00-17:30 Room 628

Ruming Zhang

Technical University of Berlin, Germany

Co-Author(s): Ruming Zhang

Abstract:

The radiation condition is the key question in the mathematical modelling for scattering problems in unbounded domains. Mathematically, it plays the role as the boundary condition at the infinity, which guarantees the well-posedness of the mathematical problem; physically, it describes the far-field asymptotic behaviour of the physical waves. In this paper, we focus on the radiation conditions for scattering problems above (locally perturbed) periodic surfaces. According to Hu et al. (2021), the radiating solution satisfies the Sommerfeld radiation condition:

$$\frac{\partial u}{\partial r} - iku = o\left(r^{-1/2}\right)$$

Although there are literature which have studied this problem, there is no specific method for dealing with periodic structures. Due to this reason, the important properties for the periodic structures may be ignored. Moreover, the existing method is not extendable to bi-periodic structures in three dimensional spaces. In this talk, we study the radiation condition for the time-harmonic scattering problem with periodic surfaces, which is modelled by the Helmholtz equation. We introduce a novel method based on the Floquet-Bloch transform, which, to the best of the author's knowledge, is the first method that works particularly for periodic media. With this method, we improve the Sommerfeld radiation condition for the scattered field from periodic media to:

$$\frac{\partial u}{\partial r} - iku = O\left(r^{-3/2}\right)$$

More importantly, the prospect of extending this method to 3D cases is optimistic.

Special Session 145 : Dynamic Models under Uncertainty in Economics and Finance

Organizer(s): Salvatore Federico , Giorgio Ferrari , Neofytos Rodosthenous

Introduction: We propose a special session dedicated to Dynamic Models under Uncertainty in Economics and Finance, aiming to explore recent advances in the modeling, analysis, and computation of economic and financial systems influenced by uncertainty and dynamic change. This session will bring together researchers working on stochastic control, dynamic programming, robust optimization, mean-field and stochastic games, and related numerical methods. Applications may include optimal investment problems, climate and energy finance, systemic risk, and epidemiology. By fostering interdisciplinary dialogue between mathematics, economics, and finance, this session aligns with the core mission of AIMS to promote applied mathematics for real-world problems.

Regular stochastic flow and Dynamic Programming Principle for jump diffusions

Schedule: July 8 17:00-17:30 Room 740

Alessandro Bondi

Luiss University Rome, Italy

Abstract:

Given a Brownian motion W and a stationary Poisson point process p with values in $\mathbb{R}^d$, we prove a Dynamic Programming Principle (DPP) in a strong formulation for a stochastic control problem involving controlled SDEs of the form
$$dX_t = b(t, X_t, a_t) dt + \alpha \left(t, X_t, a_t \right) dW_t + \int_{\{|z| \leq 1\}} g(X_{t-}, t, z, a_t) \widetilde{N}_p(dt, dz) + \int_{\{|z| > 1\}} f(X_{t-}, t, z, a_t) \widetilde{N}_p(dt, dz), \quad X_s = x \in \mathbb{R}^d, 0 \leq s \leq t \leq T.$$
 Here N_p [resp., $\widetilde{N}_p$] is the Poisson [resp., compensated Poisson] random measure associated with p . We consider arbitrary predictable controls $a \in \mathcal{P}_T$ with values in any Borel set $B \subset \mathbb{R}^l$. The coefficients $\{b, \alpha, \text{ and } g\}$ satisfy linear growth and Lipschitz--type conditions in the x -variable, and are continuous in the control variable. Moreover, we consider the value function $v(s, x) = \sup_{a \in \mathcal{P}_T} \mathbb{E} \left[\int_s^T h(r, X_r^{s,x,a}, a_r) dr + j(X_T^{s,x,a}) \right]$, where h and j are suitable given maps, globally bounded and continuous in the x -variable and in the control variable. The DPP is a fundamental tool in stochastic control with applications in physics and mathematical finance. To prove it, we show the existence of a regular stochastic flow for the previous stochastic equation when the coefficients are independent of the control a . Notably, this regularity result is new for jump diffusions even when there is no large--jumps component, i.e., $f \equiv 0$ (cf. Kunita's recent book on stochastic flows and jump diffusions). The proof of the DPP is completed by introducing an approach that relies on a new subclass of controls in $\mathcal{P}_T$. These controls allow us to apply a basic measurable selection theorem by L. D. Brown and R. Purves.

Stationary Mean-Field singular control of an Ornstein-Uhlenbeck process

Schedule: July 8 8:30-9:00 Room 740

Federico Cannerozzi

Bielefeld University, Germany

Abstract:

Motivated by continuous-time optimal inventory management, we study a class of stationary mean-field control problems with singular controls. The dynamics are modeled by a mean-reverting Ornstein-Uhlenbeck process, and the performance criterion is given by a quadratic long-time average expected cost functional. The mean-field dependence is through the stationary mean of the controlled process itself, which enters the ergodic cost functional. We characterize the solution to the stationary mean-field control problem in terms of the equilibria of an associated stationary mean-field game, showing that solutions of the control problem are in bijection with the equilibria of this mean-field game. Finally, we solve the stationary mean-field game explicitly, thereby providing a solution to the original stationary mean-field control problem.

Turnpike properties in N-player differential games

Schedule: July 8 9:30-10:00 Room 740

Asaf Cohen

University of Michigan, USA

Co-Author(s): Jiamin Jian

Abstract:

We consider the long-time behavior of equilibrium strategies and state trajectories in a linear quadratic N -player game with Gaussian initial data. By comparing the finite-horizon game with its ergodic counterpart, we establish exponential convergence estimates between the solutions of the finite-horizon generalized Riccati system and the associated algebraic system arising in the ergodic setting. Building on these results, we prove the convergence of the time-averaged value function and derive a turnpike property for the equilibrium pairs of each player. Importantly, our approach avoids reliance on the mean field game limiting model, allowing for a fully uniform analysis with respect to the number of players N . As a result, we further establish a uniform turnpike property for the equilibrium pairs between the finite-horizon and ergodic games with N players. Numerical experiments are also provided to illustrate and support the theoretical results.

Focus or Diversification? Dynamic Allocation of Climate Technology Investments under Budget Constraints

Schedule: July 8 13:30-14:00 Room 740

Katia Colaneri

University of Rome Tor Vergata, Italy

Co-Author(s): Katia Colaneri, Alessio D'Amato and Ruediger Frey

Abstract:

Major pathways for carbon abatement include a large-scale deployment of renewable energy sources (RES) and investment in carbon capture and storage (CCS) technologies. While RES such as solar and wind power offer clean, sustainable energy, significantly expanding their share in the energy mix necessitates heavy infrastructure investment. This is primarily due to issues of intermittency and the need to upgrade or redesign existing electricity grids to ensure stability and reliability. On the other hand, CCS technologies offer a potential solution to decarbonize existing fossil fuel-based infrastructure. However, CCS remains technologically immature and economically un-viable at large scale. Significant research and development efforts are required to reach a breakthrough that would make CCS a competitive option. Given limited fiscal capacity, it may be infeasible for societies to simultaneously invest heavily in RES infrastructure and fund foundational CCS research. This paper explores this trade-off by modeling the problem as a dynamic control problem. We analyze the optimal allocation of a constrained research and investment budget over time, under uncertainty about technological breakthroughs and deployment costs. A distinctive feature of our model is the lag between investment and technological availability. Our results highlight conditions under which strategic focus - favoring one technology over another - is optimal, versus cases where technological neutrality, i.e., parallel investments in both RES and CCS, may be justified.

Cooperation, Competition, and Common Pool Resources in Mean Field Games and Extensions with Inverse Learning

Schedule: July 8 8:00-8:30 Room 740

Gokce Dayanikli

University of Illinois Urbana-Champaign, USA

Abstract:

The tragedy of the commons (TOTC) states that individual incentives result in the overuse of common pool resources (CPRs), which may have detrimental future consequences for everyone. However, in many real-life situations this does not occur, and researchers such as Nobel laureate Elinor Ostrom have suggested that mutual restraint by individuals can prevent it. In mean field games (MFGs), since individuals are insignificant and non-cooperative, TOTC is inevitable. This suggests that MFGs with CPRs must incorporate both selfishness and altruism to better capture real-world behavior. Motivated by this, we discuss equilibrium notions blending cooperative and non-cooperative actions. We introduce mixed-individual and mixed-population MFGs, together with modeling of CPRs. The former captures altruism at individual levels, while the latter represents a population composed of cooperative and non-cooperative individuals. For both, we outline equilibrium definitions, and their characterization via FBSDEs. We then present a fisheries-inspired example, discussing existence, uniqueness, and experimental results. Finally, we address the challenge that understanding intervention policies in mixed MFGs requires knowledge of individuals' altruism levels, which are unobservable. We therefore consider how these levels can be learned from data using inverse learning. (Based on works with Mathieu Lauriere, and with Xiaofei Shi, Haoyang Cao)

Existence of Strong Randomized Equilibria in Mean-Field Games of Optimal Stopping with Common Noise

Schedule: July 8 16:30-17:00 Room 740

Anna Pajola

Bielefeld University, Germany

Co-Author(s): Giorgio Ferrari

Abstract:

We study a mean-field game of optimal stopping with common noise and investigate the existence of strong solutions via a connection with the Bank-El Karoui's representation problem. Under certain continuity assumptions, where the common noise is generated by a countable partition, we show that a strong randomized mean-field equilibrium exists, in which the mean-field interaction term is adapted to the common noise and the stopping time is randomized. Furthermore, under suitable monotonicity assumptions and for a general common noise, we provide a comparative statics analysis of the set of strong mean-field equilibria with strict equilibrium stopping times. Based on a joint work with Giorgio Ferrari.

Optimal Regulation of Exhaustible Resources in a Mean-Field Model with Aggregate Uncertainty

Schedule: July 8 9:00-9:30 Room 740

Alexandros Pavlis

LSE, England

Co-Author(s): K. Kardaras, A. Pavlis N. Rodosthenous

Abstract:

We develop a continuous time mean field model of an exhaustible resource extracted by a continuum of heterogeneous price taking firms under aggregate uncertainty, where the market price is determined endogenously by the aggregate outcome and a regulator sets a time dependent tax or subsidy. We formulate the regulator's problem as a stochastic control problem over the evolving distribution of extractors, prove existence and uniqueness of an optimal policy, and establish qualitative properties of the regulator's value function and optimal control. We then provide comparative statics for key primitives and complement the theory with numerical results illustrating equilibrium dynamics and the optimal regulatory policy.

An Optimal Energy Production Problem with Energy Source Switching and Load Following Nuclear Power Plants

Schedule: July 8 14:00-14:30 Room 740

Athena Picarelli

University of Verona, Italy

Abstract:

The paper deals with a optimal energy production problem where the producer aims to match at any time a prescribed demand managing two types of energy sources: a renewable energy source subject to randomness and seasonality on one hand, and a controllable deterministic system of production (e.g. nuclear) on the other hand. The problem is formulated as a optimal switching problem over three possible regimes representing the increasing/decreasing/constancy of the nuclear production rate

Optimal Consumption and Portfolio Choice with No-Borrowing Constraint in the Kim-Omberg Model: The Complete Market Case

Schedule: July 8 14:30-15:00 Room 740

Tim Niclas Sch\"utz

Bielefeld University, Germany

Co-Author(s): Giorgio Ferrari

Abstract:

In this paper, we study an intertemporal utility maximization problem in which an investor chooses consumption and portfolio strategies in the presence of a stochastic factor and a no-borrowing constraint. In the spirit of the Kim-Omberg model, the stochastic factor represents the expected excess return of the risky asset. It is perfectly negatively correlated with shocks to the risky asset and follows an Ornstein-Uhlenbeck process, thereby capturing the mean reversion of expected excess returns--a feature well supported by empirical evidence in financial markets. The investor seeks to maximize expected utility from consumption, subject to the constraint that wealth remains nonnegative at all times. To address the dynamic no-borrowing constraint, we use Lagrange duality to transform the primal problem into a singular control problem in the dual space. We then characterize the solution to the dual singular control problem via an auxiliary two-dimensional optimal stopping problem featuring stochastic volatility, and subsequently retrieve the primal value function as well as the optimal portfolio and consumption plans. Finally, a numerical study is conducted to derive economic and financial implications.

Irreversible reinsurance: Minimization of Capital Injections in Presence of a Fixed Cost

Schedule: July 8 15:00-15:30 Room 740

Maria Laura Torrente

University of Genoa, Italy

Co-Author(s): Salvatore Federico, Giorgio Ferrari

Abstract:

We propose a model in which, in exchange to the payment of a fixed transaction cost, an insurance company can choose the retention level as well as the time at which subscribing a perpetual reinsurance contract. The surplus process of the insurance company evolves according to the diffusive approximation of the Cram er-Lundberg model, claims arrive at a fixed constant rate, and the distribution of their sizes is general. Furthermore, we do not specify any particular functional form of the retention level. The aim of the company is to take actions in order to minimize the sum of the expected value of the total discounted flow of capital injections needed to avoid bankruptcy and of the fixed activation cost of the reinsurance contract. We provide an explicit solution to this problem, which involves the resolution of a static nonlinear optimization problem and of an optimal stopping problem for a reflected diffusion. We then illustrate the theoretical results in the case of proportional and excess-of-loss reinsurance, by providing a numerical study of the dependency of the optimal solution with respect to the model's parameters.

Learning Algorithm for Mean-Field Coarse Correlated Equilibrium: A Linear Programming Approach

Schedule: July 8 17:30-18:00 Room 740

Ioannis Tzouanas

Bielefeld University, Germany

Co-Author(s): Luciano Campi, Federico Cannerozzi

Abstract:

We investigate the approximation of Coarse Correlated Equilibrium (CCE) within the framework of continuous-time mean-field games. In this setting, a regulator (or a correlation device) recommends strategies that agents have no unilateral incentive to deviate from. We begin by introducing the concept of optimal CCE and reformulating the problem using a linear programming approach to demonstrate existence under weak assumptions. Then, we focus on the approximation of these equilibria, we propose a novel no-regret primal-dual learning algorithm and prove its convergence. Finally, we provide numerical examples to illustrate our results.

Special Session 146 : Nonlinear differential equations: control, delay, and boundary value problems

Organizer(s): Irene Benedetti , Francesca Dalbono , Elisa Sovrano , Valentina Taddei

Introduction: This special session aims to bring together researchers working on the theoretical and applied aspects of nonlinear differential equations, with a particular focus on control problems, delay effects, and boundary value formulations. Nonlinear phenomena arise naturally in a wide range of disciplines including physics, biology, engineering, and economics, often leading to complex dynamical systems whose behavior is strongly influenced by time delays, constraints, and boundary interactions. Special attention will be given to innovative methods for handling nonlinearity and singularity, and to applications where delay and boundary effects play a critical role. This session aims to foster interdisciplinary discussion and collaboration, and to highlight recent advances in the study and application of nonlinear differential equations in control theory and beyond.

Which diffusion strategy is best for a prey and a predator moving with Fractional Laplacians?

Schedule: July 9 8:00-8:30 Room 427

Elisa Affili

Universite de Rouen Normandie, France

Co-Author(s): Serena Dipierro, Giovanni Giacomini, Enrico Valdinoci

Abstract:

We consider a predator and a prey moving Fractional Laplacian, letting the predator and the prey free to choose the exponent characterising the distribution of the jump lengths. Which exponent should the predator use to maximise its chance to catch the prey? And which one should the prey select to minimise the possibility of meeting the predator? In this talk, we study a functional that describes the chance of meeting taking into account both strategies. We focus in particular on the case of large initial distance and we find ranges for the parameter of fractional diffusion corresponding to the maximum (for the predator) and the minimum (for the prey) in dependence of the choice of the other species. These findings rely on very fine estimates of the fundamental solution of the fractional heat equation.

A structured model of vector-borne disease with within-host viral load and antibody dynamics

Schedule: July 9 8:30-9:00 Room 427

Paulo Amorim

FGV - EMap, Brazil

Co-Author(s): M Soledad Aronna, Debora de Oliveira Medeiros

Abstract:

We present an epidemiological model for vector-borne diseases, including within-host viral load and antibody dynamics, via structured (transport) equations. The within-host dynamics is present in the infected and recovered host compartments. The structure induces nonlinearities and nonlocalities in the formulation. We analyse the model, showing well-posedness, mass conservation, and study the characteristic curves of the transport equation. We deduce a simplified Uniform Host Response (UHR) model which includes delay-type terms. For both the full and UHR model, we determine the basic reproduction number R_0 and comment on its relation to linear stability of the disease-free equilibrium. We show with numerical experiments how the within-host dynamics influences the epidemiological outcomes. This is joint work with M.S. Aronna and D.O. Medeiros.

Controllability problem of a differential equation with memory

Schedule: July 10 8:00-8:30 Room 427

Sumit Arora

Instituto de Matematicas, Universidad de Talca, Chile

Co-Author(s): Sumit Arora and Rodrigo Ponce

Abstract:

In this talk we address control problems governed by a semilinear evolution equation with memory kernel $\kappa \in L^1_{loc}(\mathbb{R}^+)$. We discuss the existence of a mild solution and the approximate controllability of both linear and semilinear control systems. To this end, we introduce the concept of a resolvent family associated with the linear evolution equation with memory and its essential properties. Subsequently, we consider a linear-quadratic regulator problem to determine the optimal control that yields approximate controllability for the linear control system. Furthermore, sufficient conditions for the existence of a mild solution and the approximate controllability of a semilinear system in a reflexive Banach space having uniformly convex dual has been presented. Finally, we apply our theoretical findings to investigate the approximate controllability of the heat equation with singular memory. Recently, Pandolfi \cite{LP-2021} studied the approximate controllability of a general class of control systems with singular memory by applying boundary control. The considered system particularly includes systems with fractional derivatives and integrals as well as the standard heat equation. Pandolfi, L.: Controllability properties for equations with memory of fractional type, Appl. Math. Optim., 84(1) (2021) 325--353.

Periodic solutions for second order time and state-dependent delay equations with a non-asymptotic condition

Schedule: July 10 13:30-14:00 Room 427

Pierluigi Benevieri

University of São Paulo, Brazil

Abstract:

We investigate the existence of periodic solutions, of a given period ω , to a class of non-autonomous second order differential equations with time and state-dependent delay. We assume that the associated linear part contains a friction term and the nonlinearity satisfies a non-asymptotic condition. We present some applications to superlinear problems and to a sunflower-type equation with variable delay. The approach is topological, based on Mawhin's coincidence degree. This is a joint work with Pablo Amster

Shock wavefronts for parabolic equation with sign-changing diffusivity

Schedule: July 10 10:30-11:00 Room 427

Diego Berti

University of Turin, Italy

Abstract:

This talk focuses on a reaction-diffusion equation in a one-dimensional space, where the diffusion is positive-negative-positive and the reaction term is bistable and changes sign where the diffusivity is negative. In this setting, continuous wavefronts are not allowed. We prove the existence of a family of shock wavefronts with profiles that have a jump discontinuity. We further investigate the properties of these profiles and their propagation speeds. Moreover, we discuss the application of the results to a model describing the movement of a population composed of both isolated and grouped individuals. This is joint work with Andrea Corli (University of Ferrara) and Luisa Malaguti (University Modena and Reggio Emilia).

Bifurcation of periodic solutions from central force problems

Schedule: July 9 16:30-17:00 Room 427

Alberto Boscaggin

University of Turin, Italy

Co-Author(s): Walter Dambrosio and Guglielmo Feltrin

Abstract:

I will discuss the existence of periodic solutions bifurcating from a manifold of periodic solutions of a central force problem in a Euclidean space of dimension two or three. The use of proper systems of coordinates will be the essential step in verifying the needed non-degeneracy condition. Joint works with Walter Dambrosio and Guglielmo Feltrin.

Evolutionary partial differential equations with finite memory: state space representation approach and the linear quadratic problem

Schedule: July 10 8:30-9:00 Room 427

Francesca Bucci

Università degli Studi di Firenze, Italy

Co-Author(s): Francesca Bucci

Abstract:

A functional-analytic reformulation of the heat equation with finite memory in a bounded domain, subjected to boundary control actions, brings about an integro-differential equation in a Hilbert space where the memory pertains to both the state and control variables; the resulting unbounded control operator occurs in the convolution term, besides the free dynamics generator. In the case of smooth kernels, an approach to the study of certain sought-after control-theoretic properties of the solutions -- such as, e.g., controllability -- utilizes MacCamy's trick along with the theory of Volterra integral equations of the second kind, and then operator semigroup theory. In this talk we will describe current work toward obtaining a representation formula for the solutions, based on a "state space representation" approach, inspired by the one introduced by C. Dafermos to deal with evolution equations with infinite memory and pursued since the 1970s on. The distinct tasks and technical challenges which need to be handled will be discussed, particularly but not exclusively with an eye to the study of the associated optimal control problem with quadratic functionals. (The talk is based on ongoing joint work with Paolo Acquistapace, Univ. di Pisa (Ret.).)

First and Second Order Nonlocal Evolution Equations Governed by Non Autonomous Forms

Schedule: July 10 14:00-14:30 Room 427

Vittorio Colao

University of Calabria, Italy

Abstract:

We present existence results for semilinear non autonomous evolution equations with nonlocal initial conditions, covering both first and second-order problems. In the first-order setting, a finite-dimensional reduction combined with the Leray Schauder continuation principle yields solutions in L^2 , under demicontinuity and transversality assumptions on the nonlinearity. The second-order analysis relies on fundamental solution techniques and Schauder type fixedpoint arguments for wave equations. Superlinear nonlinearities are handled via maximal regularity and energy inequalities in uniformly smooth Banach spaces. Applications include vibrating membranes, population dynamics with memory effects, and parabolic problems with logistic or Nagumo type reactions.

On anisotropic fractional inverse problems

Schedule: July 10 11:00-11:30 Room 427

Simone Creo

Sapienza Universita' di Roma, Italy

Abstract:

In this talk we study the well-posedness of an inverse problem modeling anisotropic diffusion, involving a fractional time derivative of Caputo type of order $\alpha \in (0, 1)$. More precisely, we consider a fractional-in-time abstract Cauchy problem involving a finite sum of operators, multiplied by suitable positive conductivities, which are considered as unknowns in the inverse problem. We prove the uniqueness of the solution of the inverse problem under suitable additional conditions and we provide a conditioned existence result. Then, we study the behavior of the solution of the inverse problem as $\alpha \rightarrow 1^-$.

Random Dynamical Systems generated by Random Generalized Ordinary Differential Equations

Schedule: July 9 13:30-14:00 Room 427

Marcia Federson

Universidade de Sao Paulo, Brazil

Co-Author(s): Xiaoying Han and Antonio Veloso

Abstract:

Within the framework of random generalized ordinary differential equations, which combine stochastic processes with generalized integration in the sense of Kurzweil, we establish new conditions ensuring the existence of solutions and, under suitable assumptions, their uniqueness, covering local, maximal, and global regimes. This setting connects deterministic generalized differential equations with random dynamical systems, providing a unified framework and new analytical tools for the study of dynamics under randomness.

On the splitting of Neumann eigenvalues in perforated domains

Schedule: July 9 17:00-17:30 Room 427

Veronica Felli

University of Milano-Bicocca, Italy

Abstract:

We address the problem of splitting of eigenvalues of the Neumann Laplacian under singular domain perturbations. We consider a domain perturbed by the excision of a small spherical hole shrinking to an interior point. We establish that the splitting of multiple eigenvalues is a generic property: if the center of the hole is located outside a set of Hausdorff dimension $N-1$ and the radius is sufficiently small, multiple eigenvalues split into branches of lower multiplicity. The proof relies on the validity of an asymptotic expansion for the perturbed eigenvalues in terms of the scaling parameter.

A paradigmatic superlinear boundary value problem: an overview of recent advances

Schedule: July 10 14:30-15:00 Room 427

Guglielmo Feltrin

University of Udine, Italy

Abstract:

We first review the main features of the paradigmatic class of superlinear boundary value problems

$-u'' = \lambda u + a(x)u^p$, $u(0) = u(L) = 0$, where $p > 1$, $\lambda \in \mathbb{R}$ is regarded as a parameter, and $a(x)$ is a weight function.

Next, we present a solution to a conjecture by R. G\u00f6mez-Re\u00fasco and J. L\u00e1pez-G\u00f3mez (JDE, 2000) concerning the multiplicity of positive solutions. This is a joint work in collaboration with Juli\u00e1n L\u00e1pez-G\u00f3mez (Universidad Complutense de Madrid) and Juan Carlos Sampedro (Universidad de Cantabria).

Subharmonics for homoclinic trajectories via Melnikov theory

Schedule: July 10 15:00-15:30 Room 427

Matteo Franca

University of Florence, Italy

Abstract:

Consider a 2-dimensional system which has a trajectory $\gamma(t)$ homoclinic to the origin, which is assumed to be a critical point; Melnikov theory provides a condition sufficient for the persistence of $\gamma(t)$ to small non-autonomous perturbation of size $0 < \varepsilon < \varepsilon_0$. Namely, a certain computable function $M(\tau)$ is required to have a non degenerate zero, say $M(\tau_0) = 0 \neq M'(\tau_0)$. In this talk we want to show that, if we add a sign condition on $M'(\tau_0)$, i.e. $M'(\tau_0) > 0$, then for any $k \in \mathbb{N}$ we find an ε_k such that the perturbed system admits at least $k + 1$ homoclinic trajectories, each performing exactly $j = 1, \dots, k + 1$ loops. On the other hand if $M'(\tau_0) < 0$ we just find persistence of the homoclinic performing a single loop. The talk is based on a joint preprint with M. Pospisil and A. Sfecci.

Structure of Optimal Solutions for Traffic Flow

Schedule: July 9 9:00-9:30 Room 427

Mauro Garavello

University of Milano-Bicocca, Italy

Co-Author(s): Fabio Ancona, Annalisa Cesaroni, Giuseppe Maria Coclite

Abstract:

In the last years, starting with the seminal papers by Lighthill and Whitham \cite{LW} and Richards \cite{richards}, there was an increasing interest in conservation laws for the modeling of traffic flow in road networks, mainly justified by applications. Particularly, the problems of reducing congestions, car accidents, and pollution have been tackled with various approaches. We present, in this talk, a way for controlling traffic flow, through a control function acting at the level of junctions \cite{a-c-c-g-1}. We introduce the concept of solution, we show that the solution exists and that, in some cases, the input-output map is continuous. It is also addressed the problem of minimization of functionals describing traffic performance indexes \cite{a-c-c-g-2}. Finally, in the case of 1-1 junctions, the structure of optimal solutions is presented \cite{a-c-c-g-3}. \bibitem{a-c-c-g-1} F. Ancona, A. Cesaroni, G. M. Coclite, M. Garavello. On the optimization of conservation law models at a junction with inflow and flow distribution controls. SIAM J. Control Optim. 56 (2018), no. 5, pp. 3370-3403. \bibitem{a-c-c-g-2} F. Ancona, A. Cesaroni, G. M. Coclite, M. Garavello. On optimization of traffic flow performance for conservation laws on networks. Minimax Theory Appl. 6 (2021), no. 2, pp. 205-226. \bibitem{a-c-c-g-3} F. Ancona, A. Cesaroni, G. M. Coclite, M. Garavello. On the structure of optimal solutions of conservation laws at a junction with one incoming and one outgoing arc. arXiv 2507.10090. \bibitem{LW} M. J. Lighthill, G. B. Whitham. On kinematic waves. II. A theory of traffic flow on long crowded roads. Proc. Roy. Soc. London. Ser. A. 229 (1955), pp. 317-345. \bibitem{richards} P.I. Richards. Shock waves on the highway. Operations Res. 4 (1956), pp. 42-51.

On semilinear non autonomous nonlocal equations

Schedule: July 9 14:00-14:30 Room 427

Maria Rosaria Lancia

Sapienza Universit a di Roma, Italy

Co-Author(s): Simone Creo

Abstract:

I will explore non-autonomous fractional (in space and/or time) semilinear BVPS, possibly in irregular domains. The focus will be on well-posedness and regularity results for the mild solutions of the corresponding semilinear Cauchy problem, via the evolution family $U(t, s)$. I will also present results on the ultracontractivity properties of the evolution family and discuss some applications and open problems.

Convergence results for varying measures under convexity conditions and applications

Schedule: July 9 14:30-15:00 Room 427

Valeria Marraffa

Dipartimento di Matematica e Informatica, Italy

Co-Author(s): A.R. Sambucini

Abstract:

Some limit theorems of the type

$$\int_{\Omega} f_n dm_n \rightarrow \int_{\Omega} f dm$$

are presented for scalar, (vector), (multi)-valued sequences of m_n -integrable functions f_n . Conditions for the convergence of sequences of measures $(m_n)_n$ and of their integrals $(\int f_n dm_n)_n$ in a measurable space Ω are of interest in many areas of pure and applied mathematics. Sufficient conditions in order to obtain some kind of Vitali's convergence theorems for a sequence of (multi)functions $(f_n)_n$ integrable with respect to a sequence of measures $(m_n)_n$ are considered. We consider the asymptotic properties of $(\int_{\Omega} f_n dm_n)_n$ with respect to varying measures, which are setwisely convergent in measurable spaces.

Consequently, a continuous dependence result for a wide class of differential equations with many interesting applications, namely measure differential equations (including Stieltjes differential equations, generalized differential problems, impulsive differential equations with finitely or countably many impulses and also dynamic equations on time scales) is provided.

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Marraffa, B. Satco, Convergence Theorems for Varying Measures Under Convexity Conditions and Applications, Mediterr. J. Math., (2022), 19:274. \bibitem{4} V. Marraffa, A.R. Sambucini, Vitali theorems for varying measure, Symmetry 2024, 16(8), 972.

Global positive bounded solutions for second order nonlinear equations with regularly varying operator

Schedule: July 10 15:30-16:00 Room 427

Serena Matucci

Department of Mathematics and Computer Sciences, Italy

Co-Author(s): Zuzana Do{\v{s}}l{\`a} and Mauro Marini

Abstract:

A second order nonlinear differential equation with inhomogeneous differential operator Φ , which is regularly varying at zero, is considered. The operator Φ can be viewed as an extension of the p -Laplacian operator and arises in many physical problems, as we will illustrate by several examples. In particular, the existence of global positive bounded solutions on the half-line with the Neumann type boundary conditions is studied by means of an abstract fixed point theorem and certain properties of an associated half-linear equation. The results do not require the explicit form of the inverse operator of Φ , and are completed by an asymptotic analysis of these solutions near infinity.

An interpolation approach to L^∞ a priori estimates for elliptic problems with nonlinearity on the boundary

Schedule: July 9 17:30-18:00 Room 427

Nsoki Mavinga

Swarthmore College, USA

Co-Author(s): Maya Chhetri, Rosa Pardo

Abstract:

In this talk, we present an explicit $L^\infty(\Omega)$ a priori estimate for weak solutions to semilinear elliptic equations with nonlinearity on the boundary, in terms of the powers of their $H^1(\Omega)$ norms. We combine an appropriate version of a Moser iteration argument along with elliptic regularity and Gagliardo--Nirenberg interpolation inequality to prove our result. We illustrate our result with an application to subcritical problems satisfying Ambrosetti-Rabinowitz condition.

Some uniqueness and multiplicity results in predator-prey models with saturation

Schedule: July 9 9:30-10:00 Room 427

Eduardo Muñoz-Hernández

Complutense University of Madrid, Spain

Co-Author(s): Kousuke Kuto and Julián López-Gómez

Abstract:

In this talk we present some results on uniqueness and multiplicity results in diffusive predator-prey models with saturation. Depending on the saturation amplitude, we will see how to obtain either uniqueness or multiplicity of coexistence states in the system. This talk is based on joint works with Julián López-Gómez (Complutense University of Madrid) and Kousuke Kuto (Waseda University).

Convergence of asymptotic systems in Cohen-Grossberg neural network models with unbounded delays

Schedule: July 10 9:00-9:30 Room 427

José J. Oliveira

University of Minho, Portugal

Co-Author(s): A. Elmwafy, José J. Oliveira, and César M. Silva

Abstract:

In this presentation, we present sufficient conditions for the convergence of asymptotic systems in non-autonomous Cohen-Grossberg neural network models that incorporate both infinite discrete time-varying and distributed delays. The main stability criterion is obtained by imposing conditions under which the non-delay terms asymptotically dominate the delay terms. As an applications, we provide sufficient conditions ensuring that all solutions of a non-periodic neural network model with unbounded delays converge to a periodic function as time goes to infinity. A numerical example is presented to illustrate the effectiveness of the new results.

Optimal strategies for differential problems with feedback controls and distributed delay

Schedule: July 10 9:30-10:00 Room 427

Paola Rubbioni

University of Perugia, Italy

Abstract:

The topic of this talk concerns our recent studies on optimal strategies for differential equations with distributed delay. By employing topological methods and tools from multivalued analysis, we establish the existence of controlled trajectories that minimize or maximize a cost functional associated with the system. The framework allows for the presence of impulses and feedback controls. The results apply to models arising in the natural and applied sciences, such as population dynamics, driven by differential equations with Volterra type distributed delays involving fading memory kernels or with functional unbounded delay.

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- [1] Benedetti I., Rubbioni P.; Impulsive delay differential inclusions applied to optimization problems, arXiv:2512.21275, pp. 1-20
- [2] Rubbioni, P.; Optimal Solutions for a Class of Impulsive Differential Problems with Feedback Controls and Volterra-Type Distributed Delay: A Topological Approach. *Mathematics* 2024, 12, 2293
- [3] Rubbioni P.; Existence of optimal periodic strategies in a model with nonlocal spatiotemporal dispersal, *J. Math. Anal. Appl.* 556 (2026) 130095

Limiting behavior of principal eigenvalues for a class of mixed boundary value problems as the measure of the support domain goes to zero

Schedule: July 9 18:00-18:30 Room 427

Alejandro Sahuquillo

Universidad Complutense de Madrid, Spain

Co-Author(s): Julián López-Gómez

Abstract:

In this paper we characterize the limiting behavior of the principal eigenvalue, $\sigma_1[-\Delta, \beta, \Omega]$, of the boundary value problem (1.1) as the Lebesgue measure of the underlying domain, Ω , tends to zero. Naturally, the domains Ω are assumed to be included on a fixed open set D such that $\beta \in \mathcal{C}(D)$, and they satisfy $\bar{\Omega} \subset D$. Our main result establishes that, in the classical case when $\inf_D \beta > 0$,

$$\lim_{|\Omega| \downarrow 0} \sigma_1[-\Delta, \beta, \Omega] = +\infty,$$

whereas

$$\lim_{|\Omega| \downarrow 0} \sigma_1[-\Delta, \beta, \Omega] = -\infty \text{ if } \sup_D \beta < 0,$$

which is a surprising result at the light of the classical existing theorems for Dirichlet boundary conditions. Furthermore, in the special case when $\beta > 0$ is a constant, we can prove that

$$\lim_{R \downarrow 0} (R\sigma_1[-\Delta, \beta, B_R]) = \beta \frac{\text{Area}(\partial B_1)}{|B_1|},$$

where, we are denoting $B_\varrho := \{x \in \mathbb{R}^N : |x| < \varrho\}$ for all $\varrho > 0$. This is a joint work with Julián López-Gómez.

Boundary value problems with Stieltjes derivative

Schedule: July 9 15:00-15:30 Room 427

Bianca Satco

Stefan cel Mare University of Suceava, Romania

Abstract:

Let $g : [0, T] \rightarrow \mathbb{R}$ be a left-continuous nondecreasing function and μ_g the Lebesgue-Stieltjes measure generated by g on $[0, T]$. The aim of the talk is to present an existence result (see [1]) for first order set-valued problems with a very general boundary condition
$$\left\{ \begin{array}{l} u'_g(t) \in F(t, u(t)), \\ \mu_g\text{-a.e. } t \in [0, T] \\ L(u(0), u(T)) = 0 \end{array} \right.$$
 involving the Stieltjes derivative with respect to g (see [2]). The multifunction $F : [0, T] \times \mathbb{R} \rightarrow \mathcal{P}(\mathbb{R})$ is of Carathéodory type with convex compact values and $L : \mathbb{R}^2 \rightarrow \mathbb{R}$ is continuous and nonincreasing with respect to its second argument. The applied method is that of lower and upper solutions inspired from [3]. The announced result generalizes several already known outcomes since the theory of Stieltjes differential equations encompasses various classical problems: ordinary differential equations (when g is the identity map), impulsive differential problems (if g can be written as a sum of the identical function with a sum of Heaviside functions) and dynamic equations on time scales. Moreover, for particular maps L some existence results for Stieltjes differential inclusions with initial value conditions ($L(x, y) = x - y$) or with periodic conditions ($L(x, y) = x - y$) are covered.

Symmetry breaking for biharmonic H^2 non type problems with exponential nonlinearities

Schedule: July 10 11:30-12:00 Room 427

Cristina Tarsi

Università degli Studi di Milano, Italy

Co-Author(s): Marta Calanchi

Abstract:

Let $B \subset \mathbb{R}^4$ be the unit ball. We discuss different maximization problems for exponential-type nonlinearities with weights of H^2 non type,

$$F_m(u) = \int_B \left(e^{\sigma u^2} - \sum_{k=0}^m \frac{\sigma^k u^{2k}}{k!} \right) |x|^\alpha \quad m \geq 0,$$

by varying u in $H^2_{\mathcal{N}}(B) = H^1_0(B) \cap H^2(B)$, in $H^2_0(B)$ and in their radial subspaces. It is well known that, as a consequence of Adams' type inequalities, all the suprema are finite if $\sigma \leq 32\pi^2$. We first prove that, in the radial framework, the finiteness of the suprema is enlarged up to $\sigma_\alpha = 32\pi^2(1 + \frac{\alpha}{4})$. Then, for $\sigma \leq 32\pi^2$ and $m \geq 1$, we prove that radial symmetry of maximizers in the whole spaces $H^2_{\mathcal{N}}(B)$ and $H^2_0(B)$ is broken for large values of the weight exponent α . These results extend classical ones in the second-order setting to the biharmonic context in the limiting dimension $N = 4$. This is a joint work with Marta Calanchi (Università degli Studi di Milano, Italy).

Bifurcation approach for periodic solutions in a superlinear BVP

Schedule: July 9 18:30-19:00 Room 427

Andrea Tellini

Universidad Politécnica de Madrid, Spain

Co-Author(s): Eduardo Muñoz-Hernández, Juan Carlos Sampedro

Abstract:

I will show how a bifurcation approach can be applied to a periodic superlinear boundary value problem also for eigenvalues with even multiplicity. This approach allows us to obtain existence and multiplicity results for local and global branches of periodic solutions with a certain nodal behavior. The optimality of such results will be also discussed with the aid of numerical simulations. These results have been obtained in collaboration with Eduardo Muñoz-Hernández (Universidad Complutense de Madrid, Spain) and Juan Carlos Sampedro (Universidad de Cantabria, Spain).

The degenerate quenching problem

Schedule: July 10 12:00-12:30 Room 427

Rafayel Teymurazyan

KAUST, Saudi Arabia

Co-Author(s): D.J. Araújo, J.M. Urbano

Abstract:

We study minimizers of non-differentiable functionals modeled on the degenerate quenching problem. Our main result establishes the finiteness of the $(n-1)$ -dimensional Hausdorff measure of the free boundary. The proof is based on optimal gradient decay estimates obtained from an intrinsic Harnack-type inequality, along with a detailed analysis in a flatness regime, where minimizers enjoy improved regularity. Our arguments provide an alternative proof of classical results of Phillips and, although developed in the degenerate setting, also offer insights relevant to the singular case.

Standing waves for the wave equation with hyperbolic boundary conditions

Schedule: July 9 15:30-16:00 Room 427

Enzo Vitillaro

Dipartimento di Matematica e Informatica Università degli Studi di Perugia, Italy

Abstract:

We deal with standing waves for the wave equation with hyperbolic boundary conditions, posed in a bounded domain with regular boundary. These problems possess a wide literature, including the papers on Arch. Rat. Mech. Anal. (2017), J.D.E. (2018) and DCDS-S (2021) by the author. Standing waves solutions of this evolution problem, in the linear setting, turn out to be eigenfunctions for a doubly elliptic problem, which involves the Laplace operator inside the domain and the Laplace-Beltrami one at the boundary. In the talk we show how these eigenfunctions constitute a Hilbert basis of a suitable space, and we study some of their properties.

Special Session 147 : From optimal control to large population games: Learning and Applications

Organizer(s): Gokce Dayanikli , Mathieu Lauriere

Introduction: This session explores a broad range of topics, from single-agent optimal control problems to large population games, with a strong emphasis on recent advances in learning-based methods and their practical applications. For large population systems, the presentations will cover developments in mean field game and control theory, including extensions that incorporate heterogeneity through network-based models or diverse agent types. Topics may include graphon games, Stackelberg mean field games, and major-minor mean field frameworks. On the learning side, presentations will involve machine learning and reinforcement learning techniques in both single-agent and multi-agent contexts. The session will also highlight real-world applications of optimal control and mean field game theory in areas such as finance, epidemic control, and energy markets.

A Mean Field Games Perspective on Evolutionary Clustering

Schedule: July 6 14:30-15:00 Room 827

Fabio Camilli

Univ. di Chieti Pescara, Italy

Co-Author(s): Alessio Basti, Adriano Festa

Abstract:

We propose a control-theoretic framework for evolutionary clustering based on Mean Field Games (MFG). Unlike traditional static or heuristic approaches, we recast the problem as a population dynamics game governed by a coupled Hamilton-Jacobi-Bellman and Fokker-Planck system. Driven by variational cost functional rather than predefined statistical shapes, this continuous-time formulation naturally accommodates non-parametric cluster evolution. To analytically validate our general framework, we analyze the specific setting of time-dependent Gaussian mixtures. We prove that the MFG dynamics explicitly recover the trajectories of the classic Expectation-Maximization algorithm, providing a rigorous generalization that guarantees mass conservation. Furthermore, we introduce time-averaged log-likelihood functionals to smooth short-term fluctuations. Numerical experiments confirm the validity of our approach in parametric contexts and pave the way for fully non-parametric clustering applications where classical EM methods are not applicable.

Vector-valued robust stochastic control with applications to finance

Schedule: July 6 15:00-15:30 Room 827

Igor Cialenco

Illinois Institute of Technology, USA

Co-Author(s): Gabriela Kovacova

Abstract:

We study a dynamic stochastic control problem subject to Knightian uncertainty with multi-objective (vector-valued) criteria. Assuming the preferences across expected multi-loss vectors are represented by a given preorder, we address the model uncertainty by adopting a robust or minimax perspective, minimizing expected loss across the worst-case model. Using a set-valued framework, we derive both a weak and a strong version of the dynamic programming principle (DPP) or Bellman equations for two appropriately chosen value functions: the collection of all worst expected losses across all feasible actions, and for its upper image. The weak version of Bellman's principle is proved under minimal assumptions. To establish a stronger version of DPP, we introduce the rectangularity property with respect to a general preorder. We also show that the weak minimizers obey the time consistency property. Finally, we study the important particular case of component-wise partial order of vectors, and conclude with some illustrative examples motivated by financial problems.

Ranking Quantitized Mean-Field Games with an Application to Early-Stage Venture Investments

Schedule: July 6 15:30-16:00 Room 827

Dena Firoozi

University of Toronto, Canada

Co-Author(s): Rinel Foguen Tchuendom, Michele Breton

Abstract:

Quantitized mean-field game models involve quantiles of the population's distribution. We study a class of such games with a capacity for ranking games, where the performance of each agent is evaluated based on its terminal state relative to the population's α -quantile value, where $\alpha \in [0, 1]$. This evaluation criterion is designed to select the top $(1 - \alpha)\%$ performing agents. We then propose an application to early-stage venture investments, where a venture capital firm supports a group of startups competing over a finite horizon, aiming to identify and fund the top-performing fraction at the end of the period.

A Preconditioned Monotone Method for Price Formation Mean Field Games

Schedule: July 6 16:30-17:00 Room 827

Diogo Gomes

KAUST, Saudi Arabia

Co-Author(s): Yeva Gevorgyan de Mendonca

Abstract:

We develop a monotone-operator numerical method for a time-dependent mean field game model of price formation, coupling Hamilton--Jacobi--Bellman and transport equations with a market-clearing condition. The system is formulated as a monotone inclusion in a weak sense that encodes the forward-backward structure and boundary conditions intrinsically. A cross-assignment structure, inherited from the HJB/Fokker--Planck duality, pairs the transport residual with a spatial Sobolev preconditioner, yielding a grid-independent Lipschitz constant. We prove convergence of a projected extragradient iteration, and validate the method against an explicit benchmark for the quadratic Hamiltonian.

A data-driven approach to time-dependent Hamilton--Jacobi--Bellman PDEs with high-order information

Schedule: July 6 17:00-17:30 Room 827

Matias Gomez-Aedo

Imperial College London, England

Co-Author(s): D. Kalise, R.B. Vinter, P. Bettiol

Abstract:

We propose a data-driven framework for approximating value functions of Hamilton--Jacobi--Bellman (HJB) equations to the time-dependent setting, targeting finite-horizon optimal control problems governed by nonlinear control-affine dynamics. The approach exploits the structural link between the Pontryagin Maximum Principle (PMP) and dynamic programming to generate augmented datasets containing values, gradients, Hessians, and temporal derivatives of the value function. A backward temporal decomposition reduces the problem to a sequence of short-horizon subproblems, on each of which the enriched data is used within a sparse polynomial regression framework based on hyperbolic cross index sets and ℓ^2 regularization. The inclusion of high-order spatial and temporal information enables accurate approximation of the value function and the associated feedback law across the full time horizon. We assess the methodology on nonlinear control problems of moderate dimension. The numerical results demonstrate that derivative-enriched regression combined with temporal decomposition yields stable and accurate approximations in Sobolev norms.

Finite Player Dynamic Games for Battery Energy Storage Intra-day Dispatch

Schedule: July 6 17:30-18:00 Room 827

Ruimeng Hu

University of California, Santa Barbara, USA

Co-Author(s): Mo Zhou, Haosheng Zhou

Abstract:

We introduce the Mean-Field Actor-Critic (MFAC) flow, a continuous-time learning dynamics for solving mean-field games (MFGs), drawing on ideas from reinforcement learning, generative modeling, and optimal transport. The MFAC framework jointly evolves the actor, critic, and distribution through gradient-based updates, with the distribution governed by a novel Optimal Transport Geodesic Picard (OTGP) flow. The OTGP flow drives the distribution toward equilibrium along Wasserstein-2 geodesics. We rigorously analyze the MFAC flow using Lyapunov functionals and establish global exponential convergence under suitable time scales. The analysis highlights the coupled structure of the algorithm and offers practical guidelines for choosing learning rates. Numerical results further support the theory and demonstrate the effectiveness of the proposed approach. This is joint work with Mo Zhou (UCLA) and Haosheng Zhou (UCSB). We develop a stochastic game-theoretic model for intraday dispatch of grid-scale battery energy storage systems (BESS). We assume that each BESS operator competitively manages her state-of-charge to maximize energy arbitrage revenues, driven by the endogenized electricity price that depends on the sum of the charging rates. We characterize the Nash equilibrium of the resulting finite-player linear-quadratic stochastic differential game with common noise, obtaining closed-form representations of equilibrium feedback controls and equilibrium price both in the general heterogeneous and the simplified homogeneous BESS setting via a system of Riccati equations. We then analyze competitive effects, including the marginal externality of additional BESS entering the market, the benefit of coordination and the corresponding market power of large operators, and supply effects from hybrid-type BESS. We further study the asymptotic regime as the number of agents grows large. Our model provides a quantitative testbed to study the impact of decentralized BESS deployment on the grid and the resulting reduction in daily price spreads. This is joint work with Mike Ludkovski and Hezhong Zhang (UCSB).

Relative Arbitrage in an Extended Mean Field System

Schedule: July 6 18:00-18:30 Room 827

Tomoyuki Ichiba

University of California Santa Barbara, USA

Co-Author(s): Nicole Tianjiao Yang

Abstract:

We consider relative arbitrage opportunities in a market with competitive investors through stochastic differential games in the limit as the number of players tends to infinity. We explore a conditional McKean-Vlasov system to study the market dynamics coupled to the expected trading volume of investors, and characterize optimal arbitrage in terms of the volatilities. Here, the mean-field interaction is considered through a joint distribution of wealth and strategies. In this setting, the optimal relative arbitrage constitutes the strong equilibrium of an extended mean-field game. We provide conditions for the existence and uniqueness of the mean-field equilibrium. We further prove the propagation of chaos result for the finite-player game counterpart, and demonstrate that the Nash equilibrium converges to the mean field equilibrium when the population grows to infinity.

Learning Nonlocal Mean Field Schrödinger Bridges

Schedule: July 7 8:00-8:30 Room 827

Daisuke Inoue

Imperial College London, England

Abstract:

In this work, we propose a learning-based framework for solving the mean-field Schrödinger bridge (MFSB) problem. The proposed four-step algorithm alternates between forward and backward drift learning, with an interaction-learning step inserted between them. This design reduces the computational cost of the MFSB problem, in which the evaluation of nonlocal interactions dominates the overall complexity. We quantify how perturbations in the learned interaction affect the resulting stochastic bridge, thereby establishing a stability guarantee for the proposed method. Numerical experiments demonstrate that our approach achieves substantial acceleration over existing solvers while maintaining comparable solution accuracy

Stability for BSDEs and backward propagation of chaos

Schedule: July 6 14:00-14:30 Room 827

Antonis Papapantoleon

TU Delft, Netherlands

Co-Author(s): Alexandros Sapiouras & Stefanos Theodorakopoulos

Abstract:

Backwards SDEs (BSDEs) are object naturally arising in the pricing and hedging of financial derivatives, and have excited the interest of the mathematical community because of their deep connections with stochastic optimal control, PDEs, and their many applications, e.g. in game theory or economics. In this talk, we will first motivate BSDEs and then consider BSDE driven by general semimartingales in a unifying framework that allows to treat discrete- and continuous-time processes simultaneously. We will discuss general existence and uniqueness results, as well as stability results, i.e. convergence from discrete- to continuous-time BSDEs. Then, we will also consider mean-field and McKean-Vlasov BSDEs, discuss their existence and uniqueness theory, and also provide a novel proof for the backward propagation of chaos, i.e. the convergence of the mean-field BSDEs to the McKean-Vlasov limit.

Inverse Reinforcement Learning for Mean-Field Games

Schedule: July 7 15:00-15:30 Room 827

Naci Saldi

Bilkent University, Turkey

Co-Author(s): Naci Saldi, Berkay Anahtarci, Can Deha Kariksiz

Abstract:

This work studies the Inverse Reinforcement Learning (IRL) problem for infinite-horizon stationary Mean Field Games (MFGs) under the maximum causal entropy principle. The unknown reward function is embedded in a Reproducing Kernel Hilbert Space (RKHS), enabling the inference of rich and nonlinear reward structures directly from expert demonstrations. This approach addresses fundamental limitations of existing IRL methods that rely on linear reward models and finite-horizon settings. A Lagrangian relaxation is introduced to reformulate the IRL objective as an unconstrained log-likelihood maximization, solved via gradient ascent. Theoretical consistency is established by proving the smoothness of the log-likelihood objective through Frechet differentiability of the associated soft Bellman operators. Numerical experiments on a mean-field traffic routing game validate the effectiveness of the method, demonstrating that the learned policies successfully replicate expert behavior.

Initialization-driven neural generation and training for high-dimensional optimal control and first-order mean field games

Schedule: July 7 8:30-9:00 Room 827

Francisco Silva

XLIM, Universite de Limoges, France

Co-Author(s): Mouhcine Assouli, Justina Gianatti, Badr Missaoui

Abstract:

This paper first introduces a method to approximate the value function of high-dimensional optimal control by neural networks. Based on the established relationship between Pontryagin's maximum principle (PMP) and the value function of the optimal control problem, which is characterized as being the unique solution to an associated Hamilton-Jacobi-Bellman (HJB) equation, we propose an approach that begins by using neural networks to provide a first rough estimate of the value function, which serves as initialization for solving the two point boundary value problem in the PMP and, as a result, generates reliable data. To train the neural network we define a loss function that takes into account this dataset and also penalizes deviations from the HJB equation. In the second part, we address the computation of equilibria in first-order Mean Field Game (MFG) problems by integrating our method with the fictitious play algorithm. These equilibria are characterized by a coupled system of a first-order HJB equation and a continuity equation. To approximate the solution to the continuity equation, we introduce a second neural network that learns the flow map transporting the initial distribution of agents. This network is trained on data generated by solving the underlying ODEs for a batch of initial conditions sampled from the initial distribution of agents. By combining this flow approximation, the previously described method for approximating the value function, and the fictitious play algorithm, we obtain an effective method to tackle high-dimensional deterministic MFGs.

Optimal Matching Strategies in Two-sided Markets: A Mean Field Approach

Schedule: July 7 9:00-9:30 Room 827

Ho Man Tai

University of Sydney, Australia

Co-Author(s): Erhan Bayraktar, Dantong Chu, Bohan Li

Abstract:

This paper develops a mean field game framework for dynamic two-sided matching markets, extending existing matching theory by integrating micro-macro dynamics in two-sided environments. Unlike traditional matching models focusing on static equilibrium or unilateral optimization, our framework simultaneously captures dynamic interactions and strategic behaviors of both market sides, as well as the equilibrium. We model two types of agents who meet each other via Poisson processes and make simultaneous matching decisions to maximize their respective objective functionals, and find the corresponding equilibrium. Our approach formulates the equilibrium as a fully coupled Hamilton-Jacobi-Bellman and Fokker-Planck system with nonlocal structure coupling two distinct populations. The mathematical analysis addresses significant challenges from the dual-layered coupling structure and nonlocal structure. We also provide insights into individual behaviors shaping aggregate patterns in labor markets through numerical experiments.

Mean-field games with rough common noise: the linear-quadratic case

Schedule: July 7 15:30-16:00 Room 827

Stefanos Theodorakopoulos

TU Berlin, Germany

Abstract:

Motivated by mean-field games (MFG) with common noise on the one hand and pathwise stochastic control theory on the other, we formulate here a linear-quadratic (LQ) MFG with rough common noise, along with a satisfactory well-posedness theory for the linear-quadratic case. A novel Volterra-type (or mild) formulation allows us to keep technical (rough-stochastic) considerations to a minimum. We derive a characterization of the optimal state and optimal control through a rough forward-backward SDE (rough FBSDE), and obtain existence and uniqueness. A number of stability estimates are established, and in particular we show continuous dependence of the Itô-Lions-Lyons map (equilibrium law as a function of the rough common noise). In a final section, we discuss independent Brownian randomization of the rough common noise. The resulting stochastic problem can be seen as an MFG extension of pathwise stochastic control problems.

Vanishing viscosity limit for Hamilton-Jacobi Equations defined in the Wasserstein space

Schedule: July 7 13:30-14:00 Room 827

Daniela Tonon

University of Padua, Italy

Co-Author(s): Giacomo Ceccherini Silberstein

Abstract:

We consider Hamilton-Jacobi equations on the Wasserstein space of probability measures, arising in deterministic and stochastic dynamics. We develop a unified viscosity solution framework for both first-order equations and semilinear equations with idiosyncratic noise, based on an appropriate choice of subdifferential compatible with comparison and stability properties. Within this framework, we establish a vanishing viscosity limit for semilinear Hamilton-Jacobi equations, showing convergence to the corresponding first-order equation as the noise intensity tends to zero, together with an optimal convergence rate. Our results provide a PDE-level description of the zero-noise transition.

Some new developments on continuous time Principal-Agent

Schedule: July 6 13:30-14:00 Room 827

Nizar Touzi

New York University, USA

Co-Author(s): P. Henry-Labordere, G. Loeper, O. Mazhar, H. Pham

Abstract:

Building on the reduction method of Sannikov and of Cvitanic-Possamai-NT, we show that, for a broad class of problems, the Principal's problem can be further characterized through the solution of a forward-backward SDE. This approach makes it possible to treat the case of a Principal facing an optimally regime-switching Agent, which had remained open in the previous literature.

Behavioral patterns, partial observability, and uncertainty in mean-field game epidemiological models

Schedule: July 7 14:00-14:30 Room 827

Alexander Vladimirovsky

Cornell University, USA

Co-Author(s): Finnegan Buckley and Carlos Doebeli

Abstract:

Details of human behavior are an important factor in the spread of infectious diseases. While in traditional epidemiological models most types of behavior (e.g., individuals' degree of compliance with social distancing recommendations) are pre-programmed, in Mean-Field Game (MFG) models individuals are assumed to make decisions (e.g., on their individual contact rates) rationally based on their current health status and the evolving epidemiological situation. But in most MFG epidemiological models, all players are assumed (a) to always have full information about their own health status, (b) to know in advance the planning horizon, (c) to be fully rational in planning their behavior, and (d) to be fully consistent in carrying out their plans. In this talk, we will show how each of these unrealistic assumptions can be relaxed, and how the resulting generalized MFG models can be treated numerically by solving a two-point boundary value problem for a system of approximating ODEs. Parts of this presentation will be based on joint papers with F. Buckley and C. Doebeli.

Dual Approaches to Stochastic Control via SPDEs and the Pathwise Hopf Formula

Schedule: July 7 14:30-15:00 Room 827

Jiefei Yang

New York University Shanghai, Peoples Rep of China

Co-Author(s): Mathieu Laurière and Jiefei Yang

Abstract:

We develop dual approaches for continuous-time stochastic control problems, enabling the computation of robust dual bounds in high-dimensional state and control spaces. Building on the dual formulation proposed in [L. C. G. Rogers, SIAM Journal on Control and Optimization, 46 (2007), pp. 1116--1132], we first formulate the inner optimization problem as a stochastic partial differential equation (SPDE); the expectation of its solution yields the dual bound. Curse-of-dimensionality-free methods are proposed based on the Pontryagin maximum principle and the generalized Hopf formula. In the process, we prove the generalized Hopf formula, first introduced as a conjecture in [Y. T. Chow, J. Darbon, S. Osher, and W. Yin, Journal of Computational Physics 387 (2019), pp. 376--409], under mild conditions. Numerical experiments demonstrate that our dual approaches effectively complement primal methods, including the deep BSDE method for solving high-dimensional PDEs and the deep actor-critic method in reinforcement learning.

Mean field games with partial information

Schedule: July 7 9:30-10:00 Room 827

Thaleia Zariphopoulou

The University of Texas at Austin, USA

Abstract:

This talk will present mean field games with relative performance criteria in market environments with partially observed model parameters. The MFG has unbounded controls both in the drift and the volatility, and common noise. A master system is derived and solved for representative cases. The single agent problem with partial information is revisited and a new solution approach will be introduced. (joint work with Panagiotis Souganidis)

Special Session 149 : Recent developments in Free Boundary Problems and Nonlinear PDEs

Organizer(s): Marvin Weidner , Aelson Sobral

Introduction: This session will highlight recent advances and emerging trends in Free Boundary Problems and Nonlinear PDEs, covering both local and nonlocal models in elliptic and parabolic contexts. Topics include qualitative properties of solutions, blow-up analysis, the geometry and regularity of interfaces, and other contemporary directions in the field. By bringing together leading experts as well as young researchers, the session will foster exchange on new techniques, open problems, and promising future directions.

Multiscale Schnauzer Estimates

Schedule: July 7 8:30-9:00 Room 639

Hector A Chang Lara

Universidade de Coimbra, Portugal

Abstract:

We present a flexible framework for proving regularity estimates for solutions of partial differential equations that does not rely on scaling invariance. This makes it particularly suited to problems where classical blow-up methods are unavailable. The approach has been used in the study of Holder regularity for parabolic equations driven by integro-differential operators, as well as in the analysis of free boundary regularity for the Hele-Shaw problem. It also applies to establish $C^{1,\alpha}$ estimates for solutions of nonlocal equations with rough kernels. As a new application, we consider the logarithmic Laplacian, a zero-order operator for which rescaling produces a non-integrable tail, creating a serious obstruction to standard compactness and blow-up arguments. In this setting, we obtain optimal Schauder-type logarithmic Holder estimates.

Constructing nontrivial global periodic solutions to the Bernoulli free boundary problem in 3D

Schedule: July 7 9:00-9:30 Room 639

Nikola Kamburov

Pontificia Universidad Catolica de Chile, Chile

Co-Author(s): Jose Basulto

Abstract:

In this talk I will present the construction of a new family of Delaunay-type solutions to the Bernoulli one-phase free boundary problem in dimension 3, starting from the double hairpin solution of Hauwirth-H\"elein-Pacard in $\mathbb{R}^2$. This is joint work with J. Basulto (UC).

Regularity of thin constraint maps

Schedule: July 7 9:30-10:00 Room 639

Sunghan Kim

Uppsala University, Sweden

Co-Author(s): Marvin Weidner, Hui Yu

Abstract:

I would like to discuss recent progress in the regularity of thin constraint maps. These are energy-minimizing maps subject to a thin constraint, which is a natural vectorial extension of the thin obstacle problem. In this sense, the problem is closely related to nonlocal obstacle problems, but it is also related to free boundary problems for harmonic maps and minimal surfaces. Analogous to thick constraint maps, thin constraint maps also develop free boundaries, due to the presence of the thin obstacle, while they also develop discontinuities, often for topological reasons. While the partial regularity theory of these maps was established in the nineties, little has been known concerning their free boundaries. In this talk, I will introduce several new results for thin constraint maps including (i) a partial regularity result that is optimal in both regularity and dimension, and (ii) the full regularity in a uniform neighborhood of their non-coincidence set even for slightly nonconvex thin obstacles. The latter result is surprisingly stronger than the thick obstacle case, where mere convexity is insufficient. My talk will be based on a joint work with Marvin Weidner (University of Bonn) and Hui Yu (National University of Singapore).

A Free Boundary Problem with Nonlocal Obstacle

Schedule: July 8 14:30-15:00 Room 639

Hayk Mikayelyan

University of Nottingham Ningbo China, Peoples Rep of China

Co-Author(s): M. Chipot, Zh. Lin

Abstract:

We consider a functional with the nonlocal obstacle acting on the function $V(x') = \int_0^1 U(x', t) dt$

$$\int_{\Omega} \frac{1}{2} |\nabla U(x)|^2 dx + \int_D V(x')^+ dx'.$$

The minimizer solves the equation

$$\Delta U(x', x_n) = \chi_{\{V>0\}}(x') + \chi_{\{V=0\}}(x') [\partial_{\nu} U(x', 0) + \partial_{\nu} U(x', 1)],$$

where $\partial_{\nu} U$ is the exterior normal derivative of U . Several regularity results are proven. It is shown that the comparison principle does not hold for minimizers, which makes numerical approximation we present somehow challenging.

A mathematical approach to epidermal wound healing

Schedule: July 7 14:00-14:30 Room 639

Katerina Nik

KAUST, Saudi Arabia

Abstract:

A mathematical model for epidermal wound closure is considered. The model is based on a moving boundary problem in which the wound edge moves once a generic epidermal growth factor exceeds a given threshold. Solutions are constructed explicitly and the existence of a waiting time before boundary motion sets in is demonstrated. The natural emergence of delay in the solution is then discussed for cases where diffusion of the growth factor concentration fails to balance the rapid motion of the wound edge.

Second-order regularity properties from one-side geometric control

Schedule: July 7 13:30-14:00 Room 639

Edgard Pimentel

University of Coimbra, Portugal

Abstract:

We establish second-order regularity properties for viscosity solutions of fully nonlinear PDE, in the presence of geometric control from below. As an application, we examine the regularity of the value functions to impulse optimal control problems.

Spectral partition problems for the divergence operator with volume and inclusion constraints

Schedule: July 8 15:00-15:30 Room 639

Makson Santos

University of Lisbon, Portugal

Co-Author(s): P^edra Andrade, Dario Mazzoleni, Ederson Moreira dos Santos, Hugo tavares

Abstract:

We study the existence and regularity of optimal partitions for a problem with volume and inclusion constraints driven by the divergence operator. In particular, we prove that an optimal partition is connected and the eigenfunction associated with each set is locally Lipschitz continuous, which implies that the optimal sets are at least open sets. We show that there is a variational formulation to our problem that does not involve subsets, only functions, and we prove the desired properties for the minimizer.

Fractional Parabolic Theory as a High-Dimensional Limit of Fractional Elliptic Theory

Schedule: July 7 8:00-8:30 Room 639

Mariana Smit Vega Garcia

Western Washington University, USA

Co-Author(s): Blair Davey

Abstract:

Since elliptic PDE theory can be seen as a steady-state version of parabolic PDE theory, if a parabolic estimate holds, then by eliminating the time parameter, one can obtain an underlying elliptic statement. Producing a parabolic statement from an elliptic statement, on the other hand, is not as straightforward. In this talk, we will discuss how a high-dimensional limiting technique can be used to prove theorems about solutions to the fractional heat equation from their elliptic counterparts.

On fractional k -Hessian operators

Schedule: July 8 14:00-14:30 Room 639

Maria Soria-Carro

Universidad Autonoma de Madrid, Spain

Co-Author(s): Mar Gonzalez and Fernando Charro

Abstract:

In this talk, I will present a fractional analogue of the classical k -Hessian operator, defined as an infimum of anisotropic fractional Laplacians over a suitable class of matrices. I will focus on the case $k = 2$ and show that, under natural assumptions, the fractional 2-Hessian operator is locally uniformly elliptic. This property places the operator within the framework of fully nonlinear integro-differential equations and makes available the regularity theory developed for nonlocal elliptic operators. The key issue is to understand the possible degeneracies in the admissible class of matrices and to prove that these degenerate directions do not contribute to the infimum. These results extend the theory known for the fractional Monge-Ampère operator ($k = n$) developed by Caffarelli et al. in 2015. This is ongoing joint work with Mar Gonzalez (UAM) and Fernando Charro (Wayne State).

Improved regularity for a nonlocal dead-core problem

Schedule: July 7 14:30-15:00 Room 639

Rafayel Teymurazyan

KAUST, Saudi Arabia

Co-Author(s): D. dos Prazeres, J.M. Urbano

Abstract:

We obtain improved regularity results for solutions to a nonlocal dead-core problem at branching points. Our approach, which does not rely on the maximum principle, introduces a new strategy for analyzing two-phase problems within the local framework, an area that remains largely unexplored.

A sharp differentiability threshold for minimizers of singular energies

Schedule: July 8 13:30-14:00 Room 639

Jose Miguel Urbano

KAUST, Saudi Arabia

Co-Author(s): Damiao Araujo (UFPB), Aelson Sobral (KAUST), and Eduardo Teixeira (OSU)

Abstract:

We address the borderline regularity of local minimizers of singular energy functionals. For bounded and measurable potentials, we show that sign-changing minimizers are Log-Lipschitz continuous, which is optimal in this generality. In the one-phase case, however, we derive gradient bounds along the free boundary, uncovering a structural gain in regularity. Our first main result establishes sharp Lipschitz regularity for a merely bounded potential. Most notably, we prove that if the potential is further assumed to be a modulus of continuity, then minimizers become continuously differentiable. We thus identify a sharp threshold for differentiability in terms of the potential's regularity.

Generic regularity of the free boundary in the Alt-Caffarelli-Phillips problem

Schedule: July 7 15:00-15:30 Room 639

Hui Yu

National University of Singapore, Singapore

Co-Author(s): Xavier Fernandez-Real

Abstract:

For generic boundary data, we discuss the improvement on the estimate of the singular dimension in the Alt-Caffarelli-Phillips problem.

Special Session 150 : Water Waves and Beyond

Organizer(s): Jörg Weber , Dag Nilsson

Introduction: Understanding the progression of waves through fluids is one of the most classical problems in mathematics and physics alike. In the context of water waves, either governed by the full Euler or suitable model equations, the vast literature deals primarily with irrotational flows in Euclidean geometry subject to appropriate boundary conditions. This special session focuses on incorporating additional aspects which are extremely important in nature: 1) Vorticity, one of the most important quantities in all of fluid dynamics. Including vortical effects creates substantial new mathematical challenges and has received great attention in recent years. 2) Boundary conditions. Instead of the classical fluid-air interaction (as for water waves), fluid-structure interactions (as in the study of sea ice or blood flow) give rise to various boundary conditions and an emerging field in theory and applications alike. 3) Geophysical aspects. These incorporate large-scale phenomena for which density/temperature stratification and the curvature and rotation of the Earth are salient physical features, and due to its great relevance in reality, this field has experienced rapid development recently. The session aims to bring together leading experts and young researchers working on these topics, with an eye towards analysis, numerics, and applications.

A fluid-solid interaction problem in porous media

Schedule: July 6 17:30-18:00 Room 639

Diego Alonso Oran

Universidad de La Laguna, Spain

Co-Author(s): Rafael Granero-Belinchon

Abstract:

In this work, we derive asymptotic interface models for an elastic Muskat free boundary problem describing Darcy flow beneath an elastic membrane. In a weakly nonlinear regime of small interface steepness, we obtain nonlocal evolution equations that capture the free-boundary dynamics up to quadratic order. In the long-wave thin-film regime, we rewrite the kinematic condition in flux form, flatten the moving domain, and derive a lubrication-type equation. Moreover, we establish well-posedness for these models in suitable Wiener spaces.

Stability of Hydroelastic Waves in Deep Water

Schedule: July 6 16:30-17:00 Room 639

Mark Blyth

University of East Anglia, England

Co-Author(s): Emilian Parau

Abstract:

In this talk we discuss two-dimensional periodic travelling hydroelastic waves on water of infinite depth. We track a bifurcation branch that connects small amplitude periodic waves to a large amplitude state in which the wave is motionless at rest and the fluid is static. The stability of the periodic waves on this branch is computed using a surface-variable formulation, computing growth rates numerically via Floquet theory. The stability spectrum including both superharmonic and subharmonic perturbations will be presented. For superharmonic perturbations the onset of instability via a Tanaka-type collision of eigenvalues at zero is identified. We shed light on the structure of the spectrum as wave amplitude increases and reveal a highly intricate structure.

Symmetric periodic and rotational three-dimensional waves in water of infinite depth

Schedule: July 7 18:00-18:30 Room 639

Stefano Boehmer

Lund University, Sweden

Abstract:

We prove existence of small, symmetric, doubly periodic and rotational gravity-capillary waves in water of infinite depth in three space dimensions. Following Lortz' ansatz from magnetohydrodynamics [1], we write the vorticity as the cross-product of two gradients and we assume the Bernoulli function to depend on the orbital period of the particles. This gives rise to a coupled elliptic-hyperbolic formulation which we cast as a fixed-point problem. Here we follow the strategy in [2], where the case of finite depth is treated. In our case the domain is not compact, which requires a more careful treatment of both the elliptic and the hyperbolic parts. Finally, we prove existence of small-amplitude solutions to the free-boundary problem with small vorticity using local bifurcation theory. This is ongoing work. [1] D. Lortz, \Uber die Existenz toroidaler magnetohydrostatischer Gleichgewichte ohne Rotationstransformation, Journal of Applied Mathematics and Physics (ZAMP), 1970 [2] D. S. Seth, K. Varholm, and E. Wahl'en, Symmetric doubly periodic gravity-capillary waves with small vorticity, Advances in Mathematics, 2024

A variational construction of solitary waves for the Babenko equation on finite depth

Schedule: July 8 8:00-8:30 Room 639

Mats Ehrnstrom

NTNU Norwegian University of Science and Technology, Norway

Co-Author(s): Tomas Dohnal, Halle University, and Johanna Marstrander, Norwegian University of Sciences and Technology

Abstract:

We construct solitary waves for the two-dimensional steady water wave problem directly from the Babenko formulation in the case of pure gravity waves over finite depth. The proof is straight-forward in the sense that it is built on constrained minimization of a scalar nonlinear and nonlocal equation as in Weinstein (1987), and a limiting procedure from periodic waves as Ehrnstr\om-Groves-Wahl'en (2012), using concentration--compactness. The novelty lies not the least in the nonlocal cubic terms appearing in the Babenko variational formulation, which carry negative order, and make nonlinear harmonic analysis an important part of the proof. The constructed smooth and localised solutions of the Babenko equation correspond to smooth and localised free-surface waves in the two-dimensional steady water wave problem over a flat bed with gravity. We show that the Babenko solitary waves are approximated by scalings of the classical Korteweg--De Vries solitary waves.

A differential inequality, an invariant set and the blow-up of high-energy solutions of a quasilinear riser equation

Schedule: July 6 18:30-19:00 Room 639

Jorge A Esquivel - Avila

Universidad Autonoma Metropolitana, Mexico

Abstract:

We consider a damped quasilinear equation of fourth order that models the mechanical vibrations of a marine riser. We study the nonexistence of global solutions, for any real value of the initial energy. For this purpose we analyze a new differential inequality and construct a new invariant set, improving the results known in the literature. We analyze the influence of the damping term on the blow-up of the solution and find a finite critical damping coefficient for which the blow-up time becomes infinite. Finally, we propose a conjecture for the existence of global solutions for any real value of the initial energy.

Ocean currents with constant vorticity

Schedule: July 8 16:30-17:00 Room 639

Anna Geyer

TU Delft, Netherlands

Co-Author(s): Ronald Quirchmayr, Calin Martin

Abstract:

In this talk I will present two recent results on time-dependent, three-dimensional water flows with constant non-vanishing vorticity. In the first part, I will discuss a rigidity result for flows with continuously depth dependent density. In the second part, I will consider the f-plane approximation for off-equatorial oceanic flows and show that these flows are necessarily steady, zonal and fully explicit, with a free surface structure that is parabolic in the latitudinal coordinate. I will also provide an application to the Antarctic Circumpolar Current (ACC) for which I compare the sea surface height predicted by our constant vorticity model with satellite altimetry measurements available in the literature.

Global bifurcation of doubly periodic water waves in Beltrami flows

Schedule: July 7 17:30-18:00 Room 639

Bastian Hilder

Technical University of Munich, Germany

Co-Author(s): Giang To (Lund University); Erik Wahlén (Lund University)

Abstract:

In this talk, I will present a global bifurcation result for doubly periodic gravity-capillary water waves with vorticity. Specifically, I consider the class of Beltrami flows, in which the velocity and vorticity fields are collinear. This structure allows us to reformulate the governing equations as a perturbation of the identity by a compact operator, enabling the application of analytic global bifurcation theory to obtain solutions along a global continuum emerging from the laminar flow. The main challenge is the presence of a two-dimensional kernel at the bifurcation point, and I will explain how this can be handled by treating the parameterisation of the local bifurcation curve as a new bifurcation parameter. This is joint work with Giang To and Erik Wahlén (both Lund University).

Think Global, Act Local: Inducing Fully Localised Planar Patterns via Spatial Heterogeneity

Schedule: July 8 8:30-9:00 Room 639

Dan J Hill

University of Oxford, England

Co-Author(s): David J.B. Lloyd, Matthew R. Turner

Abstract:

The existence of localised two-dimensional patterns has been observed and studied in numerous experiments and simulations: ranging from optical solitons, to patches of desert vegetation, to fluid convection. And yet, our mathematical understanding of these emerging structures remains extremely limited beyond one-dimensional examples. In this talk I will discuss how adding a compact region of spatial heterogeneity to a PDE model can not only induce the emergence of fully localised 2D patterns, but also allows us to rigorously prove and characterise their bifurcation. The idea is inspired by experimental and numerical studies of magnetic fluids, where our compact heterogeneity corresponds to a local spike in the magnetic field of the experiment. In particular, we obtain local bifurcation results for fully localised patterns both with and without radial or dihedral symmetry, and rigorously continue these solutions to large amplitude. Notably, the initial bifurcating solution (which can be stable at bifurcation) varies between a radially-symmetric spot and a 'dipole' solution as the width of the spatial heterogeneity increases.

The convergence of time delayed discrete model of traffic flow

Schedule: July 6 18:00-18:30 Room 639

Wei Lian

NTNU, Norway

Co-Author(s): Wei Lian

Abstract:

The problem of convergence of particle models to continuum models is fundamental. In the context of traffic flow, the rigorous proof of such convergence has been established recently for the Lighthill-Whitham-Ricardhs model. In traffic flow studies, it seems natural to introduce the effect of delay, accounting for drivers' reaction time. We consider a delayed version of Follow-the-Leader model, and aims to show the continuum limit. In this talk, we review the state of the art and present technical difficulties raised by time delay in the microscopic model, and some partial results.

Slope bounds for water waves

Schedule: July 7 16:30-17:00 Room 639

Evgeniy Lokharu

Lund University, Sweden

Abstract:

In this talk we will discuss some recent results on slope bounds for water waves.

Global bifurcation of hollow vortex streets

Schedule: July 8 9:30-10:00 Room 639

Vasileios Oikonomou

University of Missouri, USA

Co-Author(s): Samuel Walsh

Abstract:

In this talk, we will present new results on the existence of periodic configurations of hollow vortices. A hollow vortex is a region of constant pressure bounded by a vortex sheet and suspended inside a fluid, whose flow is governed by the 2D Euler equations. We will show that there exists a one-parameter family of steady, periodic hollow vortices that bifurcates from a periodic point vortex configuration and extends up to the onset of certain singularities, which we also classify. Some notable applications are the existence of von Kármán, and 2P, hollow vortex streets. The technique involves reformulating the problem using complex analysis tools, including conformal mappings and layer potential representations, then carrying out a global bifurcation argument.

Hydroelastic Waves Under Ice Covers: From Moving Loads to Variable Bathymetry

Schedule: July 6 17:00-17:30 Room 639

Emilian Parau

University of East Anglia, England

Co-Author(s): Claudia Tugulan, Olga Trichtchenko

Abstract:

Waves propagating at the surface of fluids covered by ice are considered. The waves can be generated by moving loads. The ice is modelled as an elastic or viscoelastic plate. The water is of finite depth and can have variable bathymetry. Some theoretical, numerical and experimental steady and time-dependent result in two and three-dimensions will be presented.

Instability of the halocline at the North Pole

Schedule: July 8 17:30-18:00 Room 639

Christian Puntini

University of Vienna, Austria

Co-Author(s): Christian Puntini

Abstract:

In this paper talk we discuss the instability for the near-inertial Pollard waves, as a model for the halocline in the region of the Arctic Ocean centered around the North Pole, derived in Puntini Differential and Integral Equations (2026). Adopting the short-wavelength instability approach, the stability of such flows reduces to study the stability of a system of ODEs along fluid trajectories, leading to the result that, when the steepness of the near-inertial Pollard waves exceeds a specific threshold, those waves are linearly unstable. The explicit dispersion relation of the model allows to easily compute such threshold, knowing the physical properties of the water column.

On large-scale oceanic wind-drift currents

Schedule: July 8 17:00-17:30 Room 639

Luigi Roberti

Leibniz University Hannover, Germany

Co-Author(s): Christian Puntini; Eduard Stefanescu

Abstract:

Starting from the Navier--Stokes equations in rotating spherical coordinates with constant density and eddy viscosity varying only with depth, and appropriate, physically motivated boundary conditions, we derive an asymptotic model for the description of non-equatorial wind-generated oceanic drift currents. We do not invoke any tangent-plane approximations, thus allowing for large-scale flows that would not be captured by the classical f-plane approach. The strategy is to identify two small intrinsic scales for the flow (namely, the ratio between the depth of the Ekman layer and the Earth's radius, and the Rossby number) and, after a careful scaling, perform a double asymptotic expansion with respect to these small parameters. This leads to a system of linear ordinary differential equations with nonlinear boundary conditions for the leading-order dynamics. First, we establish the existence and uniqueness of the solution to the leading-order equations and show that the solution behaves like a classical Ekman spiral for any eddy viscosity profile. Then, we discuss several cases of explicit eddy viscosity profiles (constant, linearly decreasing, linearly increasing, piecewise linear, and exponentially decaying) and compute the surface deflection angle of the wind-drift current. We obtain results that are remarkably consistent with observations.

Stratified Large-Amplitude Steady Periodic Water Waves with General Density

Schedule: July 7 17:00-17:30 Room 639

Giang To

Lund University, Sweden

Abstract:

By means of a conformal mapping and bifurcation theory, we prove the existence of large-amplitude steady stratified periodic water waves, with general density function, which may have critical layers and overhanging profiles. A nodal analysis is carried out for these solutions under certain assumption involving the Bernoulli function and the density.

Hollow desingularization of vortices

Schedule: July 8 9:00-9:30 Room 639

Kristoffer Varholm

University of Pittsburgh, USA

Co-Author(s): Robin Ming Chen, Samuel Walsh, Miles H. Wheeler

Abstract:

It is well-known that there exist a number of steady solutions with point vortices to the Euler equations. Both configurations in the plane, and embedded in water waves. In recent years there has been a program to desingularize these steady solutions, by expanding the point vortices into hollow vortices. These are essentially spinning air bubbles. In this talk I will give an overview of this effort, including work in progress on hollow vortex rings.

Special Session 151 : Encounter and Merging of Mesh-based Methods and Meshless Methods in the Era of Machine Learning

Organizer(s): Shuo Zhang , Haijun Yu , Chensong Zhang

Introduction: Computational science and engineering depend on numerical methods to solve complex PDEs and model real-world systems. Two dominant paradigms -- mesh-based methods (e.g., FEM, FDM, FVM) and meshless methods (e.g., RBF, MLS, MG) -- have long coexisted but faced complementary limitations. Mesh-based methods, while mathematically rigorous and tool-mature, struggle with high computational costs for complex geometries, adaptive refinement, and high-dimensional problems. Meshless methods, though geometrically flexible, suffer from dense matrix operations, weak error bounds, and poor scalability. Meanwhile, machine learning (ML) -- with its strengths in pattern learning, high-dimensional optimization, and surrogate modeling -- has revolutionized scientific computing. This symposium explores the convergence of these three fields, aiming to transcend traditional limitations and unlock hybrid frameworks that are robust, scalable, and versatile.

Massively parallel domain decomposition methods for solving the Helmholtz equations in $\mathcal{O}(k)$ runtime

Schedule: July 9 18:30-19:00 Room 826

Shihua Gong

The Chinese University of Hong Kong, Shenzhen, SICIAM and SLAI, Peoples Rep of China

Abstract:

We present a novel massively parallel variant of the Restricted Additive Schwarz method with Perfectly Matched Layers (RAS-PML) as a fixed point iteration for solving the Helmholtz equation in d -dimensional space and at high-frequency k . We are able to solve $\mathcal{O}(k^d)$ -scale linear systems coming from $\mathcal{O}(k^{-1})$ -diameter mesh discretizations of the Helmholtz problems in $\mathcal{O}(k)$ runtime with $\mathcal{O}(k^d)$ processors. The method is motivated by the theory in [\[arXiv:2404.02156\]](#), where the authors proved that a related Schwarz method using fixed subdomain and PML configuration has a contraction rate which decays super-algebraically fast with respect to $k \rightarrow \infty$. The proposed algorithm can be implemented easily using standard routines in the parallel domain decomposition packages.

A penalty approach for topology optimization problems

Schedule: July 8 14:30-15:00 Room 826

Wei Gong

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Yuanda Ye

Abstract:

We propose a novel penalty method framework for compliant mechanism problems, incorporating a convex nonlocal perimeter approximation scheme. We rigorously analyze the existence of solutions to the optimization problem derived from the penalty method. Furthermore, we establish that the discrete problem Gamma-converges to the continuous problem, ensuring consistency across scales. To solve the discrete problem, we develop a projected gradient method that guarantees strict monotonic descent of the objective function. Numerical experiments on the compliant mechanism and heat dissipation problems validate the effectiveness of the proposed method, with results supported by convergence analysis.

Transformer: structure conforming operator learning

Schedule: July 8 13:30-14:00 Room 826

Ruchi Guo

Sichuan University, Peoples Rep of China

Co-Author(s): Shuhao Cao, Long Chen, and Ruchi Guo

Abstract:

The Transformer has emerged as one of the most advanced neural network architectures, with wide applications in large language models (LLMs), AI for Science, and image/video process. Despite its success, its mathematical foundations remain largely open. This research presents our recent progress toward addressing this gap, structured in two parts. First, we introduce a new perspective based on Petrov-Galerkin projection and Fourier analysis to better interpret the attention mechanism. Building on this framework, we propose a modified Transformer architecture that admits a clearer mathematical interpretation and exhibits a frequency-bootstrapping property. Second, drawing inspiration from direct sampling methods (DSMs) for inverse problems, we develop a novel feature generation approach: data features are constructed by solving PDEs and then incorporated into the attention mechanism. By embedding a learnable nonlocal kernel, the DSM is naturally reformulated as such the modified attention mechanism. We demonstrate the proposed method on electrical impedance tomography (EIT), a prototypical severely ill-posed nonlinear inverse problem, which achieves superior accuracy over its predecessors and contemporary operator learners.

Lattice-Based Modeling of Cell Migration Dynamics

Schedule: July 9 17:00-17:30 Room 826

Yucheng Hu

CNU, Peoples Rep of China

Abstract:

Cell migration is a fundamental process in many biological phenomena. In this talk, I will present a lattice-based framework for modeling the dynamics of migrating cells. The lattice formulation provides a simple and intuitive way to study how microscopic movement rules give rise to collective behaviors at larger scales. Depending on the modeling assumptions, the framework can capture important features such as random motility, directional bias, adhesion. The emphasis will be on the modeling ideas and on the role of regular lattice structures as a useful tool for understanding cell migration dynamics.

On the interplay between iterative methods and error estimators

Schedule: July 8 14:00-14:30 Room 826

Yuwen Li

Zhejiang University, Peoples Rep of China

Co-Author(s): Han Shui

Abstract:

This talk presents a family of a posteriori error estimates motivated by iterative solvers. We use simple smoothers (one step of Jacobi/Gauss-Seidel iteration), on an auxiliary finer mesh to process the finite element residual for a posteriori error control. The proposed error estimators are user-friendly and robust with respect to polynomial degrees and physical parameters. Numerical experiments include Biot, convection-diffusion, Helmholtz, and Maxwell equations. The material is based on joint works with Ludmil Zikatanov and Han Shui.

Computational Imaging with Generative Models

Schedule: July 9 17:30-18:00 Room 826

Jiulong Liu

Academy of Mathematics and Systems Science, CAS, Peoples Rep of China

Abstract:

Bayesian statistical inversion and sparsity-based methods have long been effective mathematical tools for reducing sampling requirements in compressive sensing, enabling applications in underdetermined imaging systems such as MRI and CT. With the rapid advancement of deep learning, a new class of methods has emerged that learns data-driven representations, offering enhanced performance in signal and image reconstruction tasks. To address underdetermined and ill-conditioned inverse problems with limited measurements, we develop compressive sensing and Bayesian reconstruction frameworks that incorporate generative model-based priors. These approaches achieve improved reconstruction quality and computational efficiency compared to traditional regularization techniques and existing data-driven methods. Moreover, we establish theoretical guarantees for recovery performance under these generative priors. In this talk, I will present these methods and highlight recent results in applications including MRI reconstruction, phase retrieval, and other nonlinear inverse problems.

Structure-preserving parametric finite element method for surface diffusion

Schedule: July 8 15:00-15:30 Room 826

Chunmei Su

Tsinghua University, Peoples Rep of China

Abstract:

We propose a novel formulation for parametric finite element methods to simulate surface diffusion, which incorporates two scalar Lagrange multipliers and two evolution equations involving the surface area and volume, respectively, to ensure that the resulting numerical methods preserve the geometric structure of surface diffusion, i.e., the area-decreasing and volume-preserving properties. By discretizing the spatial variable using linear finite elements and the temporal variable using either the Crank-Nicolson method or the backward differentiation formulae method, we develop several high-order temporal schemes that effectively preserve the structure at a fully discrete level. These new schemes are implicit and can be efficiently solved using Newton's method. Extensive numerical experiments demonstrate that our methods achieve the desired temporal accuracy, while simultaneously preserving the geometric structure of surface diffusion.

Machine learning method with numerical Integration for singular problems

Schedule: July 9 18:00-18:30 Room 826

Hehu Xie

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Zhongshuo Lin and Yifan Wang

Abstract:

We present MRpro, an open-source image reconstruction package for MRI built upon PyTorch and open data formats. MRpro consists of three main areas. First, it provides unified datastructures for the processing and handling of MR datasets and their associated metadata, such as sampling trajectories in the Fourier domain. Second, it provides relevant mathematical concepts and operations required to build abstract reconstruction algorithms. Third, to enable the easy development of state-of-the-art learned reconstruction methods, MRpro includes essential building blocks such as so-called data-consistency layers, differentiable optimization layers and well-established neural network backbones. In this talk, we showcase different components of MRpro by considering several learned and non-learned MR imaging problems using both publicly available open-source data, numerical phantoms as well as raw scanner data, demonstrating MRpro's versatility.

Quasi-entropy: in free energies and closure approximations

Schedule: July 8 17:00-17:30 Room 826

Jie Xu

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Jie Xu

Abstract:

Molecular-theory-based tensor models of liquid crystals typically contain an explicit entropy term deduced from the maximum entropy state. For dynamic models, high-order tensors also appear in the model, for which a classical closure approximation is also given the maximum entropy state. The maximum entropy state is able to maintain the essential properties and structures of the molecular theory in tensor models, but leads to high computational cost. Quasi-entropy is a class of elementary functions to substitute the terms deduced from the maximum entropy state, which can be incorporated both in free energies and in closure approximations. It not only keeps the desired properties and structures of the models, but also reduces the complexity of dealing with implicit functions involving three dimensional integrals to $O(1)$. We present a few representative results in equilibrium states and dynamics.

A morphology-adaptive random feature method for inverse source problem of the Helmholtz equation

Schedule: July 8 15:30-16:00 Room 826

Haijun Yu

Academy of Mathematics and Systems Science, Peoples Rep of China

Co-Author(s): Xinwei Hu, Jingrun Chen and Haijun Yu

Abstract:

We propose a Morphology-Adaptive Random Feature Method (MARFM), a novel two-phase framework that adaptively locates critical regions and adds morphology activation functions for tackling the multi-frequency inverse source problem for the Helmholtz equation with complex geometry. Our framework recasts the ill-posed inverse problem into a well-posed, strictly convex optimization problem by reformulating the governing Helmholtz equation as a Tikhonov-regularized integral equation via its fundamental solution. In the first stage, the Integral Adaptive RFM (IA-RFM), employs an adaptive algorithm to rapidly localize the source support, thereby reducing computational overhead and accelerating convergence. In the second stage, posterior geometric information is progressively integrated into the solver via hybrid basis functions, enabling a precise reconstruction of complex morphologies. The MA-RFM extends the capabilities of RFM to handle PDEs with singular solutions while preserving its mesh-free efficiency. We demonstrate the superior performance of our approach through ample challenging 2D and 3D benchmark problems, even under limited and noisy measurement conditions, highlighting its robustness and accuracy in reconstructing complex and disjoint sources.

Some trainer friendly meshless methods

Schedule: July 8 17:30-18:00 Room 826

Shuo Zhang

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

The training process for the neural network problems may suffer from the super parameters and the non-convex formulation. Typical examples include the boundary condition imposition by penalty and the problem of saddle-point essence. This talk discusses how to impose the boundary condition for PINN and how to solve the saddle-point formulation physical model in friendly ways. The main proposal is to formulate the problems as convex energy-minimization problems to be friendly for optimizers. Though neural network problems are used for illustration, the methods essentially work for general meshless methods.

Weak Generative Sampler

Schedule: July 9 16:30-17:00 Room 826

Xiang ZHOU

City University of Hong Kong, Hong Kong

Co-Author(s): Zhiqiang Cai, Yu Cao, Yuanfei Huang,

Abstract:

The current deep learning-based method solves the stationary Fokker--Planck equation to determine the invariant probability density function in the form of deep neural networks, but they generally do not directly address the problem of sampling from the computed density function. Traditional numerical solvers for stochastic differential equations require both a fine step size and a lengthy simulation period, resulting in biased and correlated samples. In this work, we introduce a framework that employs a weak generative sampler (WGS) to directly generate independent and identically distributed (iid) samples induced by a transformation map derived from the stationary Fokker--Planck equation. Our proposed loss function is based on the weak form of the Fokker--Planck equation, integrating normalizing flows to characterize the invariant distribution and facilitate sample generation from a base distribution. Our randomized test function circumvents the need for min-max optimization in the traditional weak formulation. Our method necessitates neither the computationally intensive calculation of the Jacobian determinant nor the invertibility of the transformation map. A crucial component of our framework is the adaptively chosen family of test functions in the form of Gaussian kernel functions with centers related to the generated data samples. Experimental results on several benchmark examples demonstrate the effectiveness and scalability of our method, which offers both low computational costs and excellent capability in exploring multiple metastable states.

Efficient simulation under a population genetics model of carcinogenesis

Schedule: July 8 16:30-17:00 Room 826

Tianqi Zhu

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

Cancer results from somatic mutations disrupting cell division, with the number of required mutations varying by cancer type. The waiting time for m mutations in a cell is a key parameter in carcinogenesis models, which are theoretically complex due to interactions of mutation, drift, and selection, and computationally expensive to simulate due to large cell populations and low mutation rates. We present an efficient algorithm to simulate the waiting time under a population genetics model of cancer. Our hybrid method combines an exact algorithm for small populations with a coarse-grained τ -leaping approximation for large populations. Comparisons with exact simulations for small populations and asymptotic results for large populations confirm the algorithm's accuracy and computational efficiency. We applied it to study waiting times for up to 20 mutations in a Moran model with variable population sizes. This algorithm may facilitate the study of realistic carcinogenesis models incorporating variable mutation rates and fitness effects.

Special Session 152 : Recent advances in kinetic theory

Organizer(s): Mirco Piccinini , Francesca Anceschi

Introduction: By bringing together various experts as well as young researchers in kinetic theory our main purpose is to address recent developments in this area, both in the local and nonlocal setting. In particular, we will focus on regularity theory and qualitative properties of solutions, as well as their geometrical interpretation.

Moment preserving Young's inequality for the Boltzmann gain operator with hard-spheres

Schedule: July 8 16:30-17:00 Room 432

Ioakeim Ampatzoglou

CUNY Baruch College & Graduate Center, USA

Co-Author(s): Tristan L`eger

Abstract:

We will discuss a new moment-preserving, polynomially weighted Young's inequality for the gain operator of the Boltzmann equation with hard potentials, including the critical case of hard-spheres. Our approach relies crucially on a novel cancellation mechanism dealing with the pathological case of energy-absorbing collisions (that is, collisions that accumulate energy to only one of the outgoing particles). These collisions distinguish hard potentials from Maxwell molecules. Our method quantifies the heuristic that, while energy-absorbing collisions occur with non-trivial probability, they are statistically rare, and therefore do not affect the overall averaging behavior of the gain operator. At the technical level, our proof relies solely on tools from kinetic theory, such as geometric identities and angular averaging.

Global Sobolev theory for Kolmogorov-Fokker-Planck operators with coefficients measurable in time and VMO in space

Schedule: July 9 13:30-14:00 Room 432

Stefano Biagi

Politecnico di Milano, Italy

Co-Author(s): Marco Bramanti

Abstract:

We consider Kolmogorov--Fokker--Planck operators of the form

$$\mathcal{L}u = \sum_{i,j=1}^q a_{ij}(x,t)u_{x_i x_j} + \sum_{k,j=1}^N b_{jk}x_k u_{x_j} - \partial_t u,$$

with $(x,t) \in \mathbb{R}^{N+1}$, $N \geq q \geq 1$. We assume that $a_{ij} \in L^\infty(\mathbb{R}^{N+1})$, the matrix $\{a_{ij}\}$ is symmetric and uniformly positive on $\mathbb{R}^q$, and the drift term

$$Y = \sum_{k,j=1}^N b_{jk}x_k \partial_{x_j} - \partial_t$$

has a structure ensuring that the corresponding model operator with constant coefficients a_{ij} is hypoelliptic, invariant with respect to a suitable Lie group operation, and 2-homogeneous with respect to a suitable family of dilations. We further assume that the coefficients a_{ij} belong to VMO with respect to the space variable and are merely bounded measurable in t . For every $p \in (1, \infty)$, we prove global Sobolev estimates of the form
$$\|u\|_{W_{X^{\{2,p\}}}(S_{\{T\}})} \leq C \left(\sum_{i,j=1}^q \|u_{x_i x_j}\|_{L^p(S_{\{T\}})} + \sum_{i=1}^N \|u_{x_i}\|_{L^p(S_{\{T\}})} + \|u\|_{L^p(S_{\{T\}})} \right) \leq C \left(\|u\|_{L^p(S_{\{T\}})} + \|u\|_{L^p(S_{\{T\}})} \right) \quad \text{where } ST = \mathbb{R}^N \times (-\infty, T) \text{ for any } T \in (-\infty, +\infty].$$

New Regularity Results for the Kolmogorov Obstacle Problem

Schedule: July 9 14:00-14:30 Room 432

David Bowman

University of Chicago, USA

Abstract:

We study the obstacle problem associated with the Kolmogorov operator $\mathcal{L} := \Delta_v - \partial_t - v \cdot \nabla_x$, which arises from the theory of optimal control in Asian-American options pricing models. This problem presents a significant departure from the elliptic and parabolic obstacle problems due to the highly degenerate hypoelliptic nature and the non-commutative Galilean group structure underlying the operator $\mathcal{L}$. Our first main contribution is to improve the known regularity of solutions, from $C_t^{0,1} \cap C_x^{0,2/3} \cap C_v^{1,1}$ to $C_{t,x}^{0,1} \cap C_v^{1,1}$. The previous result in the literature corresponds to $C^{1,1}$ regularity with respect to the Kolmogorov distance, which is the expected regularity for obstacle problems. Our method uses Bernstein's technique and draws on ideas from Evans-Krylov theory. We then use this improvement in regularity of the solution to prove the first free boundary regularity result. We show that under a standard thickness condition, the free boundary is a $C_{t,x}^{0,1/2} \cap C_v^{0,1}$ regular surface. Our arguments rely on a new monotonicity formula and a commutator estimate that are only made possible by the solution's enhanced regularity in x .

Uniqueness of Weak Solutions to the Non-cutoff Boltzmann equation

Schedule: July 8 14:30-15:00 Room 432

Dingqun Deng

Akita University, Japan

Abstract:

In this talk, we study the non-cutoff Boltzmann equation with moderately soft potentials. The uniqueness of large weak solutions is challenging due to the nonlinearity and limited regularity. To overcome these difficulties, we utilize dilated dyadic decompositions in phase space (v, ξ, η) to capture hypoellipticity and reduce the fractional derivative structure $(-\Delta_v)^s$ of the Boltzmann collision operator to a zeroth-order form. Within this framework, we establish the uniqueness of weak and large solutions under the assumption of finite L^2 - L^r energy, namely that $\|\mu^{-\frac{1}{2}}(F - \mu)\|_{L_t^\infty L_{x,v}^r} + \|\mu^{-\frac{1}{2}}(F - \mu)\|_{L_t^\infty L_{x,v}^2}$ is bounded for some sufficiently large $r > 0$. The challenges arising from large solutions are handled via a negative-order hypoelliptic estimate, which yields additional integrability in (t, x) .

Global wellposedness for the relativistic Vlasov-Maxwell-Landau system in bounded domains

Schedule: July 8 13:30-14:00 Room 432

Hongjie Dong

Brown University, USA

Co-Author(s): Yan Guo (Brown University) and Timur Yastrzhembski (Academia Sinica, Taiwan)

Abstract:

I will discuss a recent work jointly with Yan Guo and Timur Yastrzhembski, in which we established a global well-posedness theory for the relativistic Vlasov-Maxwell-Landau system in a general 3D domain with a specularly reflective, perfectly conducting boundary.

A Gehring-Type Lemma for Kinetic and Ultraparabolic Equations

Schedule: July 9 15:00-15:30 Room 432

Jessica Guerand

University of Montpellier, IMAG, France

Co-Author(s): Cyril Imbert and Clement Mouhot, Francesca Anceschi and Teresa Isernia

Abstract:

Gehring's lemma states that a function satisfying a reverse Holder inequality on subdomains has improved integrability. Originally introduced by Gehring in connection with open problems in quasiconformal mapping, it has since been adapted to study higher integrability properties of gradients of solutions to elliptic and parabolic equations. In this talk I present results obtained in different collaborations: with Cyril Imbert and Clement Mouhot for the kinetic Fokker Planck equation and with Francesca Anceschi and Teresa Isernia for nonlinear ultraparabolic equations. The key step is the establishment of a Gehring type lemma on kinetic and ultraparabolic cylindrical subdomains.

(Fractional) Hydrodynamic Limit of Linear Kinetic Equations with Multiple Conserved Quantities

Schedule: July 8 17:00-17:30 Room 432

Laura Kanzler

CNRS, LJLL Sorbonne Universite, France

Co-Author(s): Emeric Bouin, Clement Mouhot

Abstract:

The derivation of macroscopic models from kinetic equations remains a cornerstone of statistical mechanics. For systems where the equilibrium density decays rapidly (e.g., Maxwellians), a diffusive scaling typically yields classical parabolic equations for the conserved quantities in the limit. However, it has been shown - primarily for single-conservation laws - that algebraic 'fat-tailed' equilibria lead to anomalous transport characterized by fractional diffusion. This talk extends these results to linear kinetic equations that conserve mass, momentum, and energy. We characterize the scaling limits based on the equilibrium decay rate: for sufficiently fast-decaying densities, we recover a system of classical diffusion equations. Conversely, for slower algebraic decay, we derive fractional diffusion equations for mass and energy, while the momentum equation becomes trivial. The proof is based on spectral analysis and energy estimates. They are constructive and provide explicit convergence rates.

A rigidity theorem for Kolmogorov-type operators

Schedule: July 8 17:30-18:00 Room 432

Alessia Kogoj

University of Urbino, Italy

Co-Author(s): E. Lanconelli, G. Tralli

Abstract:

Let D be a bounded open subset of $\mathbb{R}^N$, and let $z_0 \in D$. Assume that the Newtonian potential of D is proportional, outside D , to the potential generated by a point mass concentrated at z_0 . Then D is a Euclidean ball centred at z_0 . This theorem, proved by Aharonov, Schiffer, and Zalcman in 1981, was extended to the caloric setting by Suzuki and Watson in 2001. In this note, we extend the Suzuki--Watson theorem to a class of hypoelliptic Kolmogorov-type operators.

Global stability of vacuum for the relativistic Vlasov-Maxwell-Boltzmann system

Schedule: July 8 15:00-15:30 Room 432

Xingyu Li

Universita degli Studi di Trieste, Italy

Abstract:

We consider the three-dimensional relativistic Vlasov-Maxwell-Boltzmann system, where the speed of light c is an arbitrary constant no less than 1, and we establish global existence and nonlinear stability of the vacuum for small initial data, with bounds that are uniform in c . The analysis is based on the vector field method combined with the Glassey-Strauss decomposition of the electromagnetic field, and does not require any compact support assumption on the initial data. A key ingredient of the proof is the derivation of a chain rule for the relativistic Boltzmann collision operator that is compatible with the commutation properties of the vector fields. These tools allow us to control the coupled kinetic and electromagnetic equations and to obtain global stability near vacuum. This is a joint work with Chuqi Cao.

Optimal Schauder estimates for kinetic Kolmogorov equations with time measurable coefficients

Schedule: July 9 14:30-15:00 Room 432

Giacomo Lucertini

Augsburg University, Germany

Co-Author(s): Stefano Pagliarani, Andrea Pascucci

Abstract:

This talk presents recent results concerning global Schauder estimates for a class of kinetic-type Kolmogorov equations. We consider operators with coefficients that are Hölder continuous in the space variables and merely measurable in time. After a brief overview of the existing literature and a comparison of different results, we focus on Schauder estimates expressed in terms of intrinsic Hölder norms, which naturally account for the non-isotropic geometry of the underlying Lie group. We will discuss the analytical technique and outline the key steps of the proof, based on a perturbation argument and fine estimates of the fundamental solution.

Convergence of Barrier Model to Specular Reflection for the Boltzmann Equation

Schedule: July 8 15:30-16:00 Room 432

Andrei Tarfulea

Louisiana State University, USA

Co-Author(s): Sayandeep Sarkar

Abstract:

When the Boltzmann equation is studied on a bounded domain Ω , certain physically motivated boundary conditions have to be used. In our context, we look at the specular reflection boundary condition, which imposes a symmetry on the solution $f(t, x, v)$ in the velocity variable based on the tangent plane at $x \in \partial\Omega$. Microscopically, this condition models the situation where particles bounce against the boundary with perfect restitution and no friction, conserving energy (but not momentum). Building the well-posedness theory for this model with such a boundary condition baked-in can be quite cumbersome (as compared to the well-posedness theory on the full space), since one must start at low-regularity. In this work we investigate an alternate approach. We study a full-space model with a Vlasov-like force field produced by a potential barrier outside of Ω . We show that, under some uniform bounds on the solution, as the potential barrier becomes infinitely strong, the solution f indeed converges to a weak solution (as constructed in Ouyang-Silvestre 2023) of the Boltzmann equation with the boundary condition. The argument mainly relies on determining the precise shape of characteristic curves produced by this potential barrier outside of Ω , and showing that they re-enter Ω quickly, and with velocity converging to that of specular reflection, in accordance with the microscopic intuition.

Optimal regularity for kinetic equations in domains

Schedule: July 9 15:30-16:00 Room 432

Marvin Weidner

University of Bonn, Germany

Co-Author(s): Xavier Ros-Oton, Kyeongbae Kim

Abstract:

The Boltzmann equation is one of the central equations in statistical mechanics and models the evolution of a gas through particle interactions. In recent years, groundbreaking work by Imbert and Silvestre has led to a conditional regularity theory for periodic solutions of the Boltzmann equation. A major open challenge is whether such a theory can be extended to bounded domains with physically relevant boundary conditions. As a first step toward understanding the boundary case, in this talk I will discuss the smoothness of solutions to linear kinetic Fokker-Planck equations in domains with specular reflection condition. While the interior regularity of such equations is well understood, their behavior near the boundary has remained open, even in the simplest case of Kolmogorov's equation. I will also mention recent results on other boundary conditions such as diffuse reflection and in-flow. This talk is based on joint works with Xavier Ros-Oton and Kyeongbae Kim.

Fisher information and the well-posedness of the multi-species Landau equation

Schedule: July 8 14:00-14:30 Room 432

Havva Yoldas

Delft University of Technology, Netherlands

Co-Author(s): Jonathan Junn\`{e} and Raphael Winter

Abstract:

I will summarise the breakthrough result by Guillen and Silvestre (Acta Math, 2025) where they show the global well-posedness of the spatially homogeneous Landau-Coulomb equation. The Landau-Coulomb equation is a kinetic equation describing the statistical evolution of a plasma dominated by long-range Coulomb interactions. The result is based on proving that the Fisher information is monotonically decreasing along the solutions of this equation. They do so by considering a lifted equation where the dimension of the velocity space is doubled. In this lifted regime, the nonlinear degenerate Landau operator turns into a linear operator. They then prove the inequalities relating the Fisher information along the Landau operator and the Fisher information along the lifted operator which is studied by a special change of variables. Their result crucially relies on the symmetry assumption for the joint distribution of two colliding particles. Finally, I will present our recent results obtained in a collaboration with J. Junn\`{e} (TU Delft) and R. Winter (Cardiff) on the multi-species Landau equation where we construct more general Lyapunov functionals removing this symmetry requirement.

Special Session 153 : Stochastic computing and structure preserving methods

Organizer(s): Yanzhao Cao , Chuchu Chen , Jialin Hong

Introduction: Stochastic computing has developed extensive and profound interactions with various branches of mathematics and with disciplines beyond mathematics, leading to the emergence of novel methodologies and research directions. This session is devoted to numerical methods and simulations for stochastic (partial) differential equations, with topics including, but not limited to, the construction and analysis of stochastic structure-preserving algorithms, stochastic ergodic methods, and related machine learning algorithms. The session seeks to provide a platform for the presentation of recent advances and the exchange of new ideas.

Symplectic Integrators from B-Series and Generating Functions for Stochastic Hamiltonian Systems

Schedule: July 9 8:00-8:30 Room 433

Cristina Anton

MacEwan University, Canada

Abstract:

We propose a new class of symplectic schemes for the strong approximation of the solutions of stochastic Hamiltonian systems. The proposed schemes are a trade-off between the stochastic Runge-Kutta methods and the symplectic methods based on generating functions. Symplectic stochastic Runge-Kutta methods use only first order derivatives of the Hamiltonians, but they satisfy many algebraic conditions, which makes strong orders above 1 hard to obtain for general stochastic Hamiltonian systems with multiplicative noise. Symplectic schemes of strong order 1.5 or higher can be obtained using generating functions, but they require higher order derivatives of the Hamiltonians. Here we propose a new family of symplectic schemes constructed by defining a generating function similar with the ones associated to symplectic stochastic Runge-Kutta methods. The proposed schemes are a generalization of the implicit midpoint rule, are symplectic by construction, and use derivatives of at most second order. We derive schemes of strong order 1.5 for general stochastic Hamiltonian systems and study their long time behaviour through numerical experiments.

Approximation of invariant measure via an explicit scheme for the stochastic Cahn-Hilliard equation

Schedule: July 9 8:30-9:00 Room 433

Wanrong Cao

Southeast University, Peoples Rep of China

Co-Author(s): Nan Deng, Yibo Wang

Abstract:

This work investigates the stochastic Cahn--Hilliard equation (SCHE) driven by additive space--time white noise. We first refine the analytical ergodic theory by proving that the continuum equation admits a unique invariant measure on the more regular state space H_α , extending the classical result of Da Prato & Debussche (1996) on the negative Sobolev space $\dot{H}_\alpha^{-1}$. To approximate long-time behaviour, we introduce an explicit fully discrete scheme that combines a finite-difference spatial discretization with a strongly tamed exponential Euler method in time. Uniform-in-time moment bounds in the L^∞ -norm are established for the numerical solution, and a uniform strong convergence estimate with an explicit rate is derived for the fully discrete approximation. Exploiting a mass-preserving minorization tailored to Neumann boundary conditions, we further show that the numerical scheme is geometrically ergodic and possesses a unique invariant measure, together with polynomial-order error bounds for approximating the exact invariant measure. Strong laws of large numbers are proved for both the continuous and discrete systems, ensuring almost-sure convergence of temporal averages to the corresponding ergodic limits. Numerical experiments corroborate the theoretical findings, including the long-time strong convergence and the accuracy of invariant measure approximation.

The law of iterated logarithm for numerical approximation of time-homogeneous Markov process

Schedule: July 9 9:00-9:30 Room 433

Xinyu Chen

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Chuchu Chen, Jialin Hong

Abstract:

The law of the iterated logarithm (LIL) for the time-homogeneous Markov process with a unique invariant measure characterizes the almost sure maximum possible fluctuation of time averages around the ergodic limit. Whether a numerical approximation can preserve this asymptotic pathwise behavior remains an open problem. In this work, we give a positive answer to this question and establish the LIL for the numerical approximation of such a process under verifiable assumptions. The Markov process is discretized by a decreasing time-step strategy, which yields the non-homogeneous numerical approximation but facilitates a martingale-based analysis. The key ingredient in proving the LIL for such numerical approximation lies in extracting a quasi-uniform time-grid subsequence from the original non-uniform time grids and establishing the LIL for a predominant martingale along it, while the remainder terms converge to zero. Finally, we illustrate that our results can be flexibly applied to numerical approximations of a broad class of stochastic systems, including SODEs and SPDEs.

A supervised learning scheme for computing Hamilton-Jacobi equation via density coupling

Schedule: July 9 9:30-10:00 Room 433

Jianbo Cui

The Hong Kong Polytechnic University, Hong Kong

Co-Author(s): Jianbo Cui; Liu Shu; Haomin Zhou

Abstract:

We propose a supervised learning scheme for the first order Hamilton--Jacobi PDEs in high dimensions. The scheme is designed by using the geometric structure of Wasserstein Hamiltonian flows via a density coupling strategy. It is equivalently posed as a regression problem using the Bregman divergence, which provides the loss function in learning while the data is generated through the particle formulation of Wasserstein Hamiltonian flow. We prove a posterior estimate on L_1 residual of the proposed scheme based on the coupling density. Furthermore, the proposed scheme can be used to describe the behaviors of Hamilton--Jacobi PDEs beyond the singularity formations on the support of coupling density. Several numerical examples with different Hamiltonians are provided to support our findings.

Structure-preserving numerical methods for stochastic differential equations

Schedule: July 9 13:30-14:00 Room 433

Raffaele D'Ambrosio

University of L'Aquila, Italy

Abstract:

This talk presents recent advances in the numerical preservation of qualitative and quantitative features in stochastic ordinary and partial differential equations, with focus on two main directions. The first concerns the geometric integration of stochastic Hamiltonian systems. Two different settings are considered: in the Ito case, the expected Hamiltonian typically displays a linear drift in time, while in the Stratonovich case the Hamiltonian is preserved pathwise. The talk discusses how suitable numerical methods reproduce these behaviors and addresses their long-time properties through backward error analysis. The second direction regards structure-preserving discretizations for dissipative stochastic problems. In this context, the focus is on the preservation of mean-square contractivity under time discretization, especially for stochastic theta-methods. The analysis shows that such contractivity can be retained under appropriate stepsize restrictions. A unifying perspective throughout the talk is the existence of a bridge between the numerical treatment of stochastic problems and the corresponding deterministic theory. This presentation is based on joint work with Helena Bisevic (Gran Sasso Science Institute), Chuchu Chen (Chinese Academy of Sciences), David Cohen (Chalmers University of Technology & University of Gothenburg), Stefano Di Giovacchino (University of L'Aquila), and Annika Lang (Chalmers University of Technology & University of Gothenburg).

Numerical Approximation of the Invariant Measure for Parabolic SPDEs with Singular Drift

Schedule: July 9 14:00-14:30 Room 433

Ludovic Goudenège

CNRS, France

Co-Author(s): Charles-Edouard Brehier, El Mehdi Haress, Jonathan Naffrichoux, Alexandre Richard

Abstract:

We study a time-space discretization scheme for the non-linear stochastic heat equation driven by space-time white noise, with a singular reaction term b modeled as a distribution. Our numerical procedure combines a finite difference method in space with an Euler scheme, together with a taming of the singular reaction term. Under suitable scaling of all numerical parameters, we obtain strong convergence results with explicit rate that allow not only the visualization of trajectories but also the exploration of long-time statistical properties. In particular, we will focus on the approximation of the invariant measure associated with the equation. By combining dissipative Lipschitz drift with a singular drift of small Besov norm, we can study the long-time behavior and provide numerical schemes that capture the invariant distribution. This is joint work with Charles-Edouard Brehier, El Mehdi Haress, Jonathan Naffrichoux, and Alexandre Richard

Strong Convergence of Positivity Preserving Explicit Numerical Approximation for n -Dimensional Superlinear SDEs

Schedule: July 9 14:30-15:00 Room 433

Qian Guo

Shanghai Normal University, Peoples Rep of China

Co-Author(s): Yongmei Cai, Xuerong Mao

Abstract:

Stochastic Differential Equations (SDEs) are intensively employed across various fields, including biology, finance, and engineering. Many prominent models in these disciplines, such as the n -dimensional Lotka-Volterra population systems and the Heston stochastic volatility model, possess unique positive solutions. However, simulating multidimensional SDEs with superlinear coefficients presents significant challenges. Standard numerical methods, like the classical Euler-Maruyama (EM) method, are known to diverge in finite time when coefficients grow super-linearly. Furthermore, most existing explicit methods fail to preserve the structural positivity of the exact solution. This talk proposes and analyzes an explicit, cost-effective numerical scheme: the Positivity Preserving Truncated Euler-Maruyama (PPTM) method. The core of this method lies in combining a truncation technique to manage superlinear growth with a positivity mapping to ensure the numerical solution remains within the positive cone $\mathbb{R}_+^n$.

Strong Convergence Order of an Operator-Splitting Finite Difference Fully Discrete Scheme for Stochastic Gross-Pitaevskii Equations

Schedule: July 9 15:00-15:30 Room 433

Linghua Kong

Jiangxi Normal University, Peoples Rep of China

Co-Author(s): Rong Gao

Abstract:

For the one-dimensional stochastic Gross-Pitaevskii equation, we propose a fully discrete finite difference scheme based on operator splitting, and establish that the scheme attains a strong convergence order of $O(\tau^2 + h^2)$, where τ and h denote the temporal and spatial step sizes, respectively. First, under suitable assumptions, we analyze the regularity of both the exact solution and the splitting solution. Subsequently, we employ the Crank-Nicolson scheme for temporal discretization and the finite difference method for spatial discretization, and establish the convergence theory of the fully discrete scheme under the condition h^2

C0 Finite Element Methods for Biharmonic and Triharmonic Problems

Schedule: July 9 16:30-17:00 Room 433

Hengguang Li

Wayne State University, USA

Co-Author(s): Peimeng Yin and Zhimin Zhang

Abstract:

Consider the biharmonic and triharmonic problems in a general polygonal domain with the simply supported boundary condition. The finite element approximation to such high-order problems often involves sophisticated construction of the bilinear form and of the finite element spaces. We propose a new C0 finite element algorithm to solve these problems. Our methods are intuitive, easy to implement, and applicable to both convex and nonconvex domains. We give finite element error analysis and report numerical results to validate the algorithms.

Symplectic methods for stochastic Hamiltonian systems: asymptotic error distributions and Hamiltonian-specific analysis

Schedule: July 9 15:30-16:00 Room 433

Yuqian Miao

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Chuchu Chen, Xinyu Chen, Jialin Hong

Abstract:

We investigate the asymptotic error distributions of symplectic methods for stochastic Hamiltonian systems and further provide Hamiltonian-specific analysis that clarifies the superiority of symplectic methods. Our contribution is threefold. First, we derive the asymptotic error distributions of symplectic methods for stochastic Hamiltonian systems with multiplicative noise and additive noise, respectively, and show that the obtained limiting stochastic processes satisfy equations retaining the Hamiltonian formulations. Second, we propose a new approach for calculating the asymptotic error distribution, revealing the connection between the stochastic modified equation and the asymptotic error distribution. Third, we characterize the limiting distribution of the normalized Hamiltonian deviation, thereby illustrating through test equations the superiority of symplectic methods for long-time simulations of the Hamiltonians, even in the limit as the step size tends to zero.

Old and new numerical methods for SPDEs: non-asymptotic uniform in time error bounds

Schedule: July 9 17:00-17:30 Room 433

Michela Ottobre

Heriot Watt University and Maxwell Institute, Edinburgh, Scotland

Co-Author(s): Can Huang, Gideon Simpson

Abstract:

We discuss numerical methods to sample from the invariant measure of a class of SPDEs with non-Lipshitz drift, focusing in particular on tamed schemes. The methods we present approximate the SPDE dynamics uniformly in time; that is, they approximate correctly both the transient and the long time behaviour. We will show this fact by providing bounds which are non-asymptotic. Moreover, we will discuss a general approach to prove non-asymptotic, uniform in time bounds for approximations of Markovian dynamics. This approach has been shown to work for a range of Markovian dynamics and associated approximations(whether the approximation is produced numerically, via particle systems or via other methods).

Geometric collocation methods for stochastic multisymplectic PDEs

Schedule: July 9 17:30-18:00 Room 433

Linyu Peng

Keio University, Japan

Co-Author(s): Ruiiao Hu

Abstract:

Extending the stochastic generalization of the variational framework originally developed for deterministic multisymplectic partial differential equations, we introduce a stochastic variational formulation that guarantees the preservation of stochastic 1-form and 2-form conservation laws, together with stochastic counterparts of Noether's theorem. Motivated by this formulation, we develop a family of stochastic collocation schemes that inherently preserve geometric structure. In particular, these methods maintain the stochastic multisymplectic 2-form at the discrete level. For linear problems, the proposed approach additionally ensures the preservation of discrete momentum.

Controllability of stochastic Maxwell system: Theory and numerical simulation

Schedule: July 9 18:00-18:30 Room 433

Liying Sun

Capital Normal University, Peoples Rep of China

Abstract:

In this tale, we study the exact controllability of stochasticMaxwell equations. First, the observability inequality for backward stochastic Maxwell equations is established via the multiplier method. Combined with duality theory, the exact controllability result of the forward equations is further proved. It is also shown that the control imposed on the diffusion term cannot be weakened. Meanwhile, a numerical method is given for the solution of such an exact control problem to verify the theoretical result

Learning deterministic and stochastic forced Hamiltonian systems

Schedule: July 9 18:30-19:00 Room 433

Tomasz Tyranowski

University of Twente, Netherlands

Co-Author(s): Benedikt Brantner

Abstract:

We present a neural network architecture capable of learning the parameter-dependent flow of a Hamiltonian system subject to external forcing, while preserving the underlying Lagrange-d'Alembert structure. We demonstrate that this architecture can learn the flows of time-dependent systems---both deterministic and stochastic---and more accurately emulate the system's energy evolution compared to general-purpose, non-structure-preserving neural networks. This results in more stable and higher-quality solutions. We also discuss prospective applications to structure-preserving model reduction of stochastic Hamiltonian systems.

Preservation of random attractor and SRB measure under numerical discretization

Schedule: July 10 8:00-8:30 Room 433

Yibo Wang

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Chuchu Chen, Jialin Hong

Abstract:

In this talk we investigate whether the random attractor and the Sinai--Ruelle--Bowen (SRB) measure can be preserved under numerical discretization for the stochastic Hopf bifurcation modeled by a nonlinear stochastic differential equation. To this end, we establish that the stochastic Hopf bifurcation under discretization induces a discrete random dynamical system. Further, we prove that this discrete system possesses a random attractor, and then derive the existence of an SRB measure by demonstrating a strictly positive numerical Lyapunov exponent. Numerical experiments visualize the retained random attractor and SRB measure for the discrete random dynamical system, revealing structures consistent with the theoretical chaotic phase.

Convergence rate of two classes of error processes for stochastic differential equations

Schedule: July 10 8:30-9:00 Room 433

Fuke Wu

Huazhong University of Science and Technology, Peoples Rep of China

Co-Author(s): Huagui Liu, Ya Wang

Abstract:

By the Cauchy problem as a bridge, this paper establishes the convergence rate of the asymptotic error process for the Euler scheme of stochastic differential equations (SDEs). When the noise is additive, the convergence rate of the stronger error process is obtained. These results fill in the gap of the current literature on the convergence of the asymptotic error process.

Special Session 154 : Optimization methods and numerical methods for nonlinear PDEs

Organizer(s): Ruchi Guo , Jun Zou , Long Chen

Introduction: Nonlinear partial differential equations (PDEs) lie at the heart of modern modeling in science and engineering, yet their analysis and simulation remain challenging due to nonconvexity, multiscale behavior, strong coupling, and nonlocal effects. This mini-symposium brings together researchers in optimization and numerical analysis to advance algorithms and theory for nonlinear PDEs, emphasizing methods that are both mathematically rigorous and computationally efficient. We aim to highlight cross-fertilization between variational principles, monotone and smooth/nonsmooth operator theory, and FEM/DG/VEM discretization and solver design.

Virtual element methods for a class of fully nonlinear elliptic PDEs

Schedule: July 8 8:30-9:00 Room 641

Andrea Cangiani

SISSA, Italy

Co-Author(s): Guillaume Bonnet, Andreas Dedner, Ricardo H. Nochetto

Abstract:

We propose and analyse H^2 -conforming arbitrary order Virtual Element Methods (VEM) for the numerical solution of uniformly elliptic Isaacs equations, a general class of fully nonlinear equations which includes the Hamilton-Jacobi-Bellman as a special case. The approach builds upon our previous work on H^2 -conforming VEM for linear elliptic problems in nondivergence form, extending the methodology to the fully nonlinear setting. A key feature of the proposed method is that the use of H^2 -conforming spaces enables a direct, arbitrary order, discretisation of second-order operators in strong form. Moreover, the direct discretization of the strong form allows for a simple weak imposition of the boundary conditions. Assuming that the differential operator satisfies the Cordes conditions, we establish the wellposedness of the VEM and derive optimal a priori error bounds in the H^2 -norm. Numerical experiments confirm the optimality of the method and its competitiveness with other approaches.

Unsupervised Phase Unwrapping via Tailed Nonconvex Optimization and Generalized Itoh Conditions

Schedule: July 8 14:00-14:30 Room 641

Huibin Chang

Tianjin Normal University, Peoples Rep of China

Co-Author(s): Bing Hu; Huibin Chang; Zhangling Chen.

Abstract:

Phase Unwrapping (PU) is a fundamental task in MRI, InSAR, and fringe projection profilometry, serving as a critical step for recovering continuous physical quantities. Conventional PU algorithms rely heavily on the Itoh continuity condition, which often fails in experimental scenarios characterized by high noise, sharp discontinuities, or undersampling, leading to severe reconstruction artifacts. This talk presents two novel unsupervised frameworks addressing these challenges. First, we introduce a nonconvex optimization model utilizing L1-L2 regularization and tail minimization. By enhancing gradient sparsity and targeting Itoh condition residuals, this approach significantly improves reconstruction accuracy for complex phase maps. Second, we integrate Deep Image Prior (DIP) with generalized Itoh conditions to establish an unsupervised, high-fidelity unwrapping framework that requires no pre-training datasets. Numerical and experimental results demonstrate that our proposed methods achieve superior signal-to-noise ratios and detail preservation compared to classical and supervised algorithms. These works offer robust and efficient computational solutions for challenging phase retrieval tasks in modern imaging.

BDFs meet projection-free iterative schemes in non-convex constrained variational minimization

Schedule: July 8 14:30-15:00 Room 641

Guozhi Dong

Central South University, Peoples Rep of China

Co-Author(s): Zikang Gong, Ziqing Xie, Shuo Yang

Abstract:

I will present a general framework for estimating constraint violations in projection-free iterative methods for minimizing energy functionals subject to pointwise constraints, which are non-convex and involve operator quadratic in the function and/or its derivatives. Our analysis proves to be universal to all projection-free methods that utilize tangent space update strategy. We show that the constraint error bounds are determined solely by the sum of finite differences (of various orders) of the iterates, which reflect (pseudo-)temporal regularities of their continuous counterparts. A new class of projection-free BDF-k second-order-flow methods are proposed achieving modified energy stability and ensuring higher order conditional/unconditional constraint consistency than existing projection-free gradient flow methods.

A posteriori error analysis and adaptivity of a space-time finite element method for the wave equation in second order formulation

Schedule: July 7 18:30-19:00 Room 641

ZHAONAN DONG

INRIA Paris, France

Abstract:

We establish rigorous a posteriori error bounds for a space-time finite element method of arbitrary order discretising linear wave problems in second order formulation. The method combines standard finite elements in space and continuous piecewise polynomials in time with an upwind discontinuous Galerkin-type approximation for the second temporal derivative. The proposed scheme accepts dynamic mesh modification, as required by space-time adaptive algorithms, resulting in a discontinuous temporal discretisation when mesh changes occur. We prove a posteriori error bounds in the $L^\infty(L^2)$ norm, using carefully designed temporal and spatial reconstructions; explicit control on the constants (including the spatial and temporal orders of the method) in those error bounds is shown. The convergence behaviour of an error estimator is verified numerically, also taking into account the effect of the mesh change. A space-time adaptive algorithm is proposed and tested numerically.

Numerical Analysis of PDE-Constrained Shape Optimization via Shape Gradient Flow

Schedule: July 8 9:30-10:00 Room 641

Wei Gong

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Chuwen Ma, Ziyi Zhang

Abstract:

In this talk, we investigate the numerical approximation of shape gradient flows arising from PDE-constrained shape optimization problems. The shape gradient flow system comprises the state equation, adjoint state equation, velocity equation, and domain evolution map. For discretization, we discuss two strategies: evolving finite element method where the mesh adapts dynamically to the evolving domain using evolving finite elements, as well as unfitted finite element method by use of a fixed background mesh enhanced with cubic splines to implicitly track domain boundaries. For both approaches, we derive rigorous a priori error estimates. Numerical experiments are provided to validate these theoretical findings.

Entropy-consistent numerical methods and singular limit for nonlocal conservation laws

Schedule: July 8 15:00-15:30 Room 641

Kuang Huang

The University of Hong Kong, Hong Kong

Co-Author(s): Giuseppe Maria Coclite, Nicola De Nitti

Abstract:

We consider a class of nonlocal conservation laws modeling traffic flow, where the velocity depends on a convolution of the density with a rescaled kernel that concentrates as a parameter ϵ tends to zero. A central question is whether solutions converge to the entropy-admissible solution of the corresponding local conservation law, and how to design numerical methods that faithfully capture this transition. We present numerical schemes that are asymptotically compatible: as the mesh size h and ϵ vanish simultaneously, numerical solutions converge to the local entropy solution with an explicit rate of order $\sqrt{\epsilon} + \sqrt{h}$. We also discuss a complementary approach via compensated compactness that resolves the singular limit for rough initial data and kernels.

An edgewise iterative scheme for the discontinuous Galerkin method with Lagrange multiplier for Poisson's equation

Schedule: July 7 17:00-17:30 Room 641

Mi Young Kim

Inha University, Korea

Co-Author(s): Dongwook Shin

Abstract:

An edgewise iterative scheme is developed for large systems of equations resulting from the discretization by the discontinuous Galerkin method with Lagrange multiplier for the Poisson's equation. The solution is computed element by element. Lagrange multiplier is edgewise updated, which is given as the average of the Robin type information on the elements sharing the edge. Analysis of the convergence of the scheme is given with the discrete maximum norm over all the edges. Several numerical experiments are presented.

Neural networks-based nonlinear preconditioning for Newton's method

Schedule: July 8 15:30-16:00 Room 641

Yuhuang Meng

Delft University of Technology, Netherlands

Co-Author(s): Jing Zhao, Alexander Heinlein

Abstract:

Many problems in computational science and engineering require solving nonlinear systems of equations arising from partial differential equations. The commonly used methods include Newton's methods and Picard's iteration methods. However, the standard Newton's method is sensitive to the initial guess and may exhibit slow convergence or even stagnation due to unbalanced nonlinearities. To address this issue, nonlinear preconditioning techniques have been developed to improve the nonlinear convergence. Constructing an efficient preconditioner can be challenging. In addition to traditional numerical approaches, a promising direction is to leverage machine learning techniques, especially given the rapid development in the field of scientific machine learning. In this talk, we will explore how neural networks can be employed to build efficient preconditioners that accelerate the convergence of Newton's methods.

Adaptive multilevel Newton methods for nonlinear PDEs

Schedule: July 7 16:30-17:00 Room 641

Eun-Jae Park

Yonsei University, Korea

Co-Author(s): D. Kim and B. Seo

Abstract:

The main part of the talk consists of an adaptive mesh-refining based on the multi-level algorithm and derive a unified a posteriori error estimate for a class of nonlinear problems in the abstract setting. The multi-level algorithm on adaptive meshes retains quadratic convergence of Newton's method across different mesh levels both theoretically and numerically. As applications of our theory, we consider the pseudostress-velocity formulation of Navier-Stokes equations and the standard Galerkin formulation of semilinear elliptic equations. Reliable and efficient a posteriori error estimators for both approximations are derived. Several numerical examples are presented to test the performance of the algorithm and validity of the theory developed. Lastly, ongoing work on Darcy-Forchheimer flows is presented.

Randomized Neural Networks for PDEs with Applications in MHD

Schedule: July 7 18:00-18:30 Room 641

Fei Wang

Xi'an Jiaotong University, Peoples Rep of China

Abstract:

The incompressible magnetohydrodynamic (MHD) equations are fundamental in modeling many physical and engineering phenomena. Yet their strong nonlinearity and two divergence-free constraints make them notoriously difficult to solve with traditional numerical methods. Recently, neural networks have gained attention for solving PDEs, but deep learning approaches often struggle: they are slow to train, get trapped in local minima, and only approximate mass conservation. In this talk, I will present a Structure-Preserving Randomized Neural Network (SP-RaNN) designed to overcome these challenges. SP-RaNN automatically and exactly enforces divergence-free conditions, avoids costly nonlinear optimization, and works in a space-time framework that preserves both physical and mathematical structures. The method linearizes the governing equations, discretizes them at collocation points, and solves the resulting system efficiently with least-squares techniques. Through applications to Navier-Stokes, Maxwell, and MHD equations, I will show that SP-RaNN achieves higher accuracy and efficiency than both traditional solvers and deep neural network methods.

A class of stabilized nonconforming finite element methods for fourth-order PDEs on surfaces

Schedule: July 8 9:00-9:30 Room 641

Shuonan Wu

Peking University, Peoples Rep of China

Co-Author(s): Hao Zhou

Abstract:

This talk presents the development and analysis of nonconforming finite element methods, specifically the Morley and New-Zienkiewicz-type (NZT) elements, for the surface biharmonic problem and the stream function formulation of the surface Stokes problem. By employing appropriate stabilization techniques and geometric approximations, we address the challenges arising from the lack of H^2 -conformity on discrete surfaces. Theoretical analysis establishes optimal convergence rates for the proposed schemes in various norms. Furthermore, we investigate the necessity and impact of stabilization terms through numerical experiments, providing insights into the robustness and efficiency of these nonconforming approximations for complex surface geometries.

Machine learning method for solving high dimensional eigenvalue problems

Schedule: July 8 13:30-14:00 Room 641

Hehu Xie

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Yifan Wang, Qi Zhou, Teng Wu, Jianghao Liu, Qingyuan Sun, Zhenli Xu

Abstract:

In this talk, we will consider the neural network-based machine learning method for solving eigenvalue problems of differential operators. Based on a new understanding of the error estimation for machine learning methods, we design a type of machine learning method with numerical integration to achieve high accuracy. As an example, we will design a tensor neural network-based machine learning method for solving high-dimensional eigenvalue problems, including the famous Schrodinger equations. Some numerical examples are provided to validate the high accuracy and efficiency of the proposed tensor neural network-based machine learning methods.

Hyperbolicity-Preserving Stochastic Galerkin Methods for Conservation Laws with Uncertainty via Associative Truncated Polynomial Products

Schedule: July 8 8:00-8:30 Room 641

Yulong Xing

The Ohio State University, USA

Co-Author(s): Haroun Meghaichi

Abstract:

Stochastic Galerkin methods offer an attractive intrusive framework for uncertainty quantification in hyperbolic conservation laws, but for nonlinear systems the projected stochastic Galerkin system may fail to preserve the hyperbolicity of the underlying equations. In this talk, we present a new framework for constructing hyperbolicity-preserving stochastic Galerkin methods for general systems of conservation laws with uncertain data. The central idea is to discretize the multiplication operator arising in the stochastic Galerkin formulation through an associative truncated polynomial product. Within this framework, we establish approximation properties, compare several choices of truncated products, and highlight the mechanisms by which the construction supports hyperbolicity preservation. We then present numerical results for the isothermal Euler equations and the compressible Euler equations with uncertain data, which demonstrate the robustness and effectiveness of the proposed approach.

A Cartesian grid method for acoustic scattering

Schedule: July 7 17:30-18:00 Room 641

Wenjun Ying

Shanghai Jiao Tong University, Peoples Rep of China

Abstract:

We present a Cartesian grid method for homogeneous and inhomogeneous scattering problems on complex domains. The method is a generalization of the traditional boundary integral method. It solves the scattering problem in the framework of boundary integral method but avoids direct evaluation of boundary and volume integrals. The evaluation is done by indirectly solving equivalent interface problems on Cartesian grids with fast solvers. For (exterior) problems on unbounded domains, we introduce an artificial circle or sphere to accelerate the solution of interface problems, while preserving accuracy. In the talk, we shall also present numerical examples to demonstrate the method.

Special Session 155 : Advances in mathematical modelling and numerical simulation of superfluids

Organizer(s): Ionut Danaila , Weizhu Bao

Introduction: This special session will address some of the most challenging recent problems concerning the mathematical modelling and numerical simulation of superfluids and related quantum systems (Bose-Einstein condensate and superfluid Helium). The objective of the session is to bring together applied and pure mathematicians, as well as computational scientists who have contributed to the development of relevant mathematical and computational models in this area. The topics which will be discussed include mathematical models for complex quantum systems (dipolar, spinor BEC, quantum turbulence, etc.), numerical methods for the Gross-Pitaevskii and related equations, high-performance computing of realistic configurations corresponding to physical quantum systems.

Computational methods for the nonlinear Schroedinger equation with low regularity potential and nonlinearity

Schedule: July 9 9:30-10:00 Room 738

Weizhu Bao

National University of Singapore, Singapore

Abstract:

In this talk, we begin with the nonlinear Schroedinger equation (NLSE) with different low regularity potentials and nonlinearities arising from modeling and simulation for quantum physics and chemistry, nonlinear/quantum optics, and quantum information and computation, etc. Optimal error bounds for time-splitting methods and exponential wave integrators are established for the NLSE under the proper regularity assumption on its solution determined by the low regularity potential and nonlinearity. Then we propose a novel symmetric and explicit Gautschi-type exponential wave integrator (sEWI) for the NLSE with low regularity potential and nonlinearity and establish its optimal error estimates under various regularity assumptions on potential and nonlinearity. Extensions to the NLSE with singular potentials and nonlinearities are presented. Finally, extensions to other dispersive PDEs with low regularity potential and nonlinearity are discussed. This talk is based on joint works with Remi Carles, Yue Feng, Bo Lin, Ying Ma, Chunmei Su, Qinglin Tang and Chushan Wang.

Supersolidity in Dipolar Bose-Einstein condensates

Schedule: July 9 8:00-8:30 Room 738

Blair P Blakie

University of Otago, New Zealand

Co-Author(s): Blair Blakie

Abstract:

What happens when a solid starts flowing like a superfluid, yet still creaks like a crystal? This is the remarkable behaviour of a supersolid - a phase of matter that combines crystalline order with frictionless flow. Once a long-standing theoretical curiosity, supersolidity has now been realised in an exceptionally clean and tunable platform: dilute dipolar Bose-Einstein condensates of highly magnetic atoms such as dysprosium and erbium. Recent experiments have used the competing effects of short-range contact and long-range dipolar interactions to self-organise these ultracold gases into periodic density modulations, while maintaining global phase coherence. In this talk, I will explore the curious world of two-dimensional dipolar supersolids. These quantum materials break multiple symmetries and exhibit up to 3 different types of sound-wave excitations. Interestingly, this quantum fluid develops a shear-modulus marking solid-like rigidity, and exhibits transverse sound waves. I will discuss the underlying theory for the ground states and excitations, and how long-wavelength properties can be described by a hydrodynamic theory that incorporates both elasticity and superfluidity.

Dynamical reduction for solitonic filaments

Schedule: July 9 13:30-14:00 Room 738

Ricardo Carretero

San Diego State University, USA

Abstract:

In this talk we describe techniques for the dynamical reduction of soliton stripes in nonlinear spatio-temporal systems. The central idea is to cast reductions to accurately describe these structures with lower-dimensional models that are more easily tackled, both mathematically and computationally. In turn, the reduced models allow for an unprecedented description of the statics, stability, dynamics, and interactions of these structures.

Numerical models for coupling Navier-Stokes and Gross-Pitaevskii solvers for two-fluid quantum flows

Schedule: July 9 17:00-17:30 Room 738

Ionut Danaila

University of Rouen Normandy, France

Abstract:

In quantum flows, like liquid helium II at intermediate temperatures between zero and 2.17 K, a normal fluid and a superfluid coexist with independent velocity fields. The most advanced existing models for such systems use the Navier-Stokes equations for the normal fluid and a simplified description of the superfluid, based on the dynamics of quantized vortex filaments, with ad hoc reconnection rules. There was a single attempt [1] to couple Navier-Stokes and Gross-Pitaevskii equations in a global model intended to describe the compressible two-fluid liquid helium II. We present in this contribution a new numerical model to couple a Navier-Stokes incompressible fluid with a Gross-Pitaevskii superfluid [2]. A numerical algorithm based on pseudo-spectral Fourier methods is presented for solving the coupled system of equations. The new numerical system is validated against well-known benchmarks for the evolution in a normal fluid of different types or arrangements of quantized vortices (vortex crystal, vortex dipole and vortex rings). [1] C. Coste, Nonlinear Schrodinger equation and superfluid hydrodynamics, The European Physical Journal B - Condensed Matter and Complex Systems, VOL. 1, P. 245--253, 1998. [2] M. Brachet, G. Sadaka, Z. Zhang, V. Kalt and I. Danaila, Coupling Navier-Stokes and Gross-Pitaevskii equations for the numerical simulation of two-fluid quantum flows, J. Computational Physics, 488, p. 112193(1-17), 2023.

Scale-by-scale scalar statistics and extreme events in non-equilibrium multicomponent flows

Schedule: July 9 14:00-14:30 Room 738

Luminita Danaila

University of Rouen Normandy, France

Abstract:

Scale-by-scale scalar statistics are investigated from first principles in non-equilibrium multicomponent flows, with particular emphasis on higher-order moments as signatures of rare and extreme events. The analysis focuses on how small-scale scalar fluctuations are shaped by large-scale gradients, advection, waves, coherent structures, and component coupling in systems where a single effective Reynolds number is insufficient to characterize the dynamics. The framework is illustrated primarily for quantum turbulence described by the Hall-Vinen-Bekharevich-Khalatnikov (HVBK) model, including temperature effects. A second case pertains to atmospheric flows simulated using the Weather Research and Forecasting (WRF) model in Large Eddy Simulation configuration, with application to heat-wave conditions over France. Although physically distinct, both systems exhibit strong mixing, variable thermodynamic properties, and a marked dependence of small-scale statistics on large-scale forcing. This parallel highlights common multiscale mechanisms governing intermittency and extreme events in non-equilibrium flows. 1. Polanco, J. I., Roche, P. E., Danaila, L., and Leveque, E. (2025). Disentangling temperature and Reynolds-number effects in quantum turbulence. *Proceedings of the National Academy of Sciences*, 122. 2. Zhang, Z., Danaila, L., Leveque, E., and Danaila, I. (2023). Higher-order statistics and intermittency in two-fluid quantum turbulence. *Journal of Fluid Mechanics*, 960, A6.

Superfluidity and phase transition in discrete clock symmetry

Schedule: July 9 14:30-15:00 Room 738

Michikazu Kobayashi

Kochi University of Technology, Japan

Abstract:

Superfluidity in superfluid helium and ultracold atoms is characterized by broken continuous $U(1)$ symmetry. In contrast to these clean systems, superconductors are highly influenced by discrete symmetry originating from crystal structure and multi-band features. To investigate the influence of the discrete symmetry, we consider the two-dimensional Gross-Pitaevskii model having the discrete $\mathbb{Z}_n$ clock symmetry and the characteristics of the superfluid phase transition. The superfluid phase transition is characterized by the number n and the strength g of the discrete symmetry $\mathbb{Z}_n$. When g is large, the superfluid phase transition is first order. When g is small, on the other hand, the phase transition is 2nd order for $n \leq 4$, and BKT-type for $n \geq 5$. Our numerical results are consistent with the variational renormalization group analysis.

Computing the action ground states of nonlinear Schrödinger equation

Schedule: July 9 16:30-17:00 Room 738

Wei Liu

National University of Defense Technology, Peoples Rep of China

Abstract:

This talk presents recent advances in numerical computation for the action ground state (GS) of the nonlinear Schrödinger equation with possible rotational effects. We first establish computationally feasible variational characterizations for the action GS: minimization problems with the Nehari constraint or the L^{p+1} -normalization for both focusing and defocusing cases, and the unconstrained action minimization specifically for the defocusing case. Then, we develop effective numerical algorithms for computing the action GS by solving these variational problems, with rigorous convergence analysis. Furthermore, by combining theoretical analysis with numerical explorations, we present results regarding the properties of the action GS, in particular revealing its non-equivalence with the energy GS.

NLS equation with competing nonlinearities: orbital stability of kinks and solitons

Schedule: July 9 9:00-9:30 Room 738

Dmitry Pelinovsky

McMaster University, Canada

Abstract:

Kinks connecting zero and nonzero equilibria in the NLS equation with competing nonlinearities occur at the special values of the frequency parameter. Since they are minimizers of energy, they are expected to be orbitally stable in the time evolution of the NLS equation. However, the stability proof is complicated by the degeneracy of kinks near the nonzero equilibrium. The main purpose of this work is to give a rigorous proof of the orbital stability of kinks. We give details of analysis and computations for the cubic-quintic NLS equation and show how the proof is extended to the general case. We also identify the orbitally stable solitons in the discrete version of this model and perform a comprehensive numerical study of all stable configurations in the anti-continuum limit of the model.

On inviscid instabilities of 2D vortices

Schedule: July 9 15:30-16:00 Room 738

Bartosz Protas

McMaster University, Canada

Co-Author(s): Vikas Krishnamurthy (IIT Hyderabad) and Dariche Nguyen (McMaster)

Abstract:

We first consider Euler flows on a 2D periodic domain and are interested in the stability, both linear and nonlinear, of a simple equilibrium given by the 2D Taylor-Green vortex. As the first main result, numerical evidence is provided for the fact that such flows possess unstable eigenvalues embedded in the band of the essential spectrum of the linearized operator. However, the unstable eigenfunction is a distribution unbounded at the hyperbolic stagnation points of the base flow and its regularity is consistent with a theorem of Lin (2004). This eigenfunction gives rise to an exponential transient growth with the rate given by the real part of the eigenvalue followed by passage to a nonlinear instability. As the second main result, we illustrate a fundamentally different, non-modal, growth mechanism involving a continuous family of uncorrelated functions, instead of an eigenfunction of the linearized operator. Constructed by solving a suitable PDE optimization problem, the resulting flows saturate the known estimates on the growth of the semigroup related to the essential spectrum of the linearized Euler operator as the numerical resolution is refined. Finally, we show that analogous mechanisms govern the linear instability of the Lamb-Chaplygin dipole. These results highlight the special stability properties of equilibria in inviscid flows. [Joint work with Xinyu Zhao (NJIT) and Roman Shvydkoy (University of Illinois at Chicago)]

Floquet geometric squeezing in fast-rotating condensates

Schedule: July 9 8:30-9:00 Room 738

Han Pu

Rice University, USA

Co-Author(s): Li Chen and Han Pu

Abstract:

Constructing and manipulating quantum states in fast-rotating Bose-Einstein condensates (BECs) has long stood as a significant challenge as the rotating speed approached a critical velocity. Although a recent experiment [R. J. Fletcher et al., Science 372, 1318 (2021)] has realized the geometrically squeezed state of the guiding-center mode, the remaining degree of freedom, the cyclotron mode, remains unsqueezed due to the large energy gap of the Landau levels. To overcome this limitation, we propose a Floquet-based state-preparation protocol by periodically driving an anisotropic potential. Through both analytical and numerical calculations, we demonstrate that this protocol not only facilitates single-cyclotron-mode squeezing, but also enables two-mode squeezing. Such two-mode squeezing offers a richer set of dynamics compared to single-mode squeezing and can achieve a wave-packet width well below the lowest-Landau-level limit. Our work provides a highly controllable knob for realizing diverse geometrically squeezed states in ultracold quantum gases within the quantum Hall regime.

High-order parametric local discontinuous Galerkin methods for anisotropic curve-shortening flows

Schedule: July 9 15:00-15:30 Room 738

Chunmei Su

Tsinghua University, Peoples Rep of China

Co-Author(s): Xiuhui Guo, Wei Jiang, Chunmei Su

Abstract:

We propose a family of high-order local discontinuous Galerkin (LDG) methods, built on a parametric representation and coupled with a semi-implicit backward Euler time discretization, for isotropic and anisotropic curve-shortening flows. The spatial LDG formulation introduces auxiliary variables and carefully designed numerical fluxes which inherit the underlying variational structure. We prove the unconditional energy dissipation for the semi-discrete scheme, and establish the well-posedness for the fully discrete scheme under mild assumptions. For P_k approximations, the LDG method achieves high-order spatial convergence; extensive numerical experiments confirm optimal $(k + 1)$ -order accuracy when the surface energy is isotropic or weakly anisotropic. Compared to classical parametric finite element methods (PFEM), the proposed LDG schemes do not need to rely on good mesh distributions or auxiliary symmetrized surface energy matrices for strongly anisotropic surface energy cases, and remain numerically stable on severely degraded meshes that typically cause PFEMs failure. This intrinsic stability enables effective capture of complex geometric evolution and sharp corner singularities produced by strong anisotropy. The approach thus provides a flexible and reliable framework for the numerical simulation of a broader class of geometric flows.

Special Session 156 : Structure and dynamics of solutions for nonlinear elliptic and parabolic equations

Organizer(s): Satoshi Tanaka , Raul Manasevich , Marta Garcia-Huidobro

Introduction: This session is dedicated to understanding the structure of solutions for nonlinear elliptic and parabolic equations. We will delve into qualitative properties such as existence, uniqueness, and stability, as well as the phenomena of bifurcation and symmetry, and related methods.

Extremal norms of potentials from fixed eigenvalues for Camassa-Holm equations

Schedule: July 9 16:30-17:00 Room 312

Jifeng Chu

Hangzhou Normal University, Peoples Rep of China

Abstract:

We study a kind of reverse spectral problems for Camassa-Holm equations. The aim is to prove the explicit solutions for the extremal L^1 -norms of the potentials, given the first fixed periodic eigenvalue or any fixed Dirichlet eigenvalue. We use the setting of measure differential equations to understand such problems because the solution will lead to Dirac measure distributions of potentials. The explicit expressions for the sharp bounds are given as some elementary functions.

On ground states to an elliptic problem involving a double phase operator

Schedule: July 9 14:30-15:00 Room 312

Marta Garcia Huidobro

Pontificia Universidad Catolica de Chile, Chile

Co-Author(s): C. Cort\'azar and P.Herreros

Abstract:

(based on a joint work with Profs. Carmen Cort\'azar and Pilar Herreros) This talk is concerned with the uniqueness of radially symmetric ground state solutions to the double phase elliptic problem

$$\operatorname{div}\big(a(|x|)|\nabla v|^{q-2}\nabla v + b(|x|)|\nabla v|^{p-2}\nabla v\big) + f(v) = 0, \quad \lim_{|x|\rightarrow+\infty} v(x) = 0, \quad x \in \mathbb{R}^n, (P)$$

where a and b are weights satisfying some growth assumptions. For simplicity in this talk we will treat the case of

$a(|x|) = |x|^{\tilde{\theta}}$, and $b(|x|) \equiv 1$, namely
$$\begin{gathered} \big(r^{\theta-1}\phi_q(u') + r^{n-1}\phi_p(u')\big)' + r^{n-1}f(u) = 0, \quad r > 0, \quad u(0) = 0, \quad \lim_{r \rightarrow +\infty} u(r) = 0, \end{gathered}$$
 where $\theta = n + \tilde{\theta} > 1$, $\phi_s(t) = |t|^{s-2}t$, $s > 1$, $n > q > p > 1$ and $' = \frac{d}{dr}$. Regarding the nonlinearity $f \in C(\mathbb{R})$, we assume the following $\text{\textit{[(f1)]}}$ f is odd, $f(0) = 0$, and there exist $0 < b < \beta < \infty$ such that $f(s) > 0$ for $s > b$, $f(s) \leq 0$, $f(s) \not\equiv 0$ for $s \in [0, b]$, $F(\beta) = 0$, where $F(s) := \int_0^s f(t)dt$. $\text{\textit{[(f2)]}}$ f is continuously differentiable in $(0, \infty)$, $f' \in L^1(0, 1)$. $\text{\textit{[(f3)]}}$ $f(x)/\phi_q(x)$ is an increasing function of x for $x > b$. $\text{\textit{[(f4)]}}$ $\left(\frac{F}{f}\right)'(s) > \max\left\{\frac{\theta}{nq} - \frac{1}{n}, \frac{1}{p} - \frac{1}{n}\right\}$, $\quad$ $s > \beta$, Regarding the weight $r^{\theta-1}$ we assume $\text{\textit{[(w1)]}}$ $\theta \geq n$, $\frac{\theta - n}{q - p} < 1$.

Multi-peak stationary solutions for the Gierer-Meinhardt model on a star shaped graph

Schedule: July 9 17:30-18:00 Room 312

Yuta Ishii

Fukuoka University, Japan

Abstract:

In this talk, we consider the multi-peak stationary solutions for the Gierer-Meinhardt model on a star shaped graph. Here, a star shaped graph is a network-like domain joining several edges in a single junction. In particular, we are interested in the effect of the geometry of the domain on the location of the spikes.

Asymmetry of positive solutions for the Helmholtz equation in unbounded domains

Schedule: July 9 9:00-9:30 Room 312

Ryuji Kajikiya

Osaka Electro-Communication University, Japan

Abstract:

We investigate the asymmetry of positive solutions for the H^1 -non equation in a reflectionally symmetric or a point symmetric domain Ω , which is unbounded but it is getting narrower near the infinity. We call $u(x)$ a least energy solution if it is a minimizer of the Rayleigh quotient associated with the H^1 -non equation. We shall prove that no least energy solution is reflectionally symmetric and even. Moreover, we prove the existence of a positive solution which has the exact symmetry of reflection.

Bifurcation structure in a prey-predator model with protection zone and directed flux

Schedule: July 9 14:00-14:30 Room 312

Kousuke Kuto

Waseda University, Japan

Co-Author(s): Kazuhiro Oeda

Abstract:

This talk studies a spatial prey-predator model incorporating protection zone for prey and directed predator flux toward high-prey-density regions. We investigate how the interaction between spatial refuge and directed movement influences qualitative structures of solutions. In particular, we analyze bifurcation structures of positive stationary solutions and describe their behavior as the directed flux becomes large. The analysis reveals saddle-node bifurcations and multiplicity of coexistence states generated by the combined effects of protection zone and directed flux. We also discuss the associated nonstationary problem and explain how solvability can be established despite discontinuities arising from the refuge interface. These results clarify how protection mechanism and directed flux jointly organize solution structures in prey-predator systems.

Sturm-Liouville boundary value problems and applications to logistic type population models

Schedule: July 9 15:30-16:00 Room 312

Kunquan Lan

Toronto Metropolitan University, Canada

Abstract:

In the presentation, I'll present the existence of nonzero nonnegative or strictly positive solutions of the boundary value problems (BVPs) of nonlinear Sturm-Liouville (S-L) differential equation:
$$(p(x)u'(x))' + q(x)u(x) = f(x, u(x)) \quad \text{for almost every } x \in [0, 1]$$
 subject to the separated boundary condition (BC):
$$\alpha u(0) - \beta u'(0) = 0, \quad \gamma u(1) + \delta u'(1) = 0,$$
 where $\alpha, \beta, \gamma, \delta \in \mathbb{R}_+$ satisfy $(\alpha + \beta)(\gamma + \delta) > 0$ and $f : [0, 1] \times \mathbb{R}_+ \rightarrow \mathbb{R}$ is allowed to take negative values and may have no lower bounds. A sufficient condition for the linear S-L homogeneous equations subject to the above BC to have only zero solution is provided for the first time. The sufficient conditions are a key toward obtaining both the Green's functions to such BVPs and uniqueness of solutions for the linear S-L nonhomogeneous BVPs including the one-dimensional elliptic BVPs.

Global continuum of solutions for systems of ODEs with periodic boundary conditions and generalized variable-exponent operators

Schedule: July 9 13:30-14:00 Room 312

Raul Manasevich

University of Chile, Chile

Co-Author(s): Jorge Novoa

Abstract:

We consider nonlinear systems of boundary-value problems in one dimension of the form

$$(\mathcal{S}(t, u'))' = f(t, u, u', \lambda),$$

subject to periodic boundary value conditions. The function $\mathcal{S} : [0, T] \times \mathbb{R}^N \rightarrow \mathbb{R}^N$ is continuous and satisfies $\mathcal{S}(0, x) = \mathcal{S}(T, x)$ for all $x \in \mathbb{R}^N$, the function f is Caratheodory. Furthermore we assume $\mathcal{S}$ satisfies some monotonicity and coercivity conditions, thereby defining a class of generalized variable exponent operators that strictly contains the Musielak Orlicz case. Using an abstract continuation framework and the Leray Schauder degree, we establish the existence of global continuum of nontrivial solutions depending on the parameter λ . Our approach builds on a degree-theoretic alternative of Fitzpatrick, Massabo, and Pejsachowicz, reducing the evaluation of the Leray Schauder degree to a Brouwer degree. This work shows how monotonicity and coercivity conditions in one dimension allow for continuum of solutions in a setting strictly more general than the Musielak Orlicz framework. Furthermore our results are new even if $\mathcal{S}$ is independent of t .

Asymptotic expansion of the heat content for polyharmonic heat equations

Schedule: July 9 18:00-18:30 Room 312

Nobuhito Miyake

Faculty of Mathematics, Kyushu University, Japan

Abstract:

We consider the asymptotic behavior of the heat content associated with polyharmonic heat equations as time approaches zero. Here, the heat content is defined as the mass of solutions over a fixed smooth compact set with initial data given by the indicator function of this set. More precisely, we derive a higher-order asymptotic expansion of the heat content and provide explicit expressions for the coefficients, which reflect the geometric properties of the boundary. We also discuss a connection between our results and a thresholding algorithm for a geometric evolution equation.

Optimal Resource Allocation in Multi-Patch Models with Sign-Changing Environments

Schedule: July 9 8:00-8:30 Room 312

Kentaro NAGAHARA

Institute of Science Tokyo, Japan

Abstract:

This talk concerns the monostable reaction-diffusion logistic equation, which arises in mathematical biology, and a spatially discretized multi-patch model. The reaction-diffusion logistic equation, also known as the Fisher-KPP equation, has been studied extensively since its introduction as a population-dynamics model (e.g., Skellam, 1951). We focus on optimal resource-allocation strategies that maximize population persistence under a fixed total amount of resources. In particular, we consider environments in which habitat quality (or resource availability) changes sign in a spatially heterogeneous manner. This leads us to study the linearized eigenvalue problem at the trivial steady state and to determine the allocation that maximizes the population's persistence. We prove that any global maximizer of the principal eigenvalue is always of bang-bang type, and this conclusion holds independently of the underlying network structure.

Variational analysis for coupled nonlinear Schrödinger equations with point interaction

Schedule: July 10 8:30-9:00 Room 312

Yuki Osada

Tokyo University of Science, Japan

Co-Author(s): Alessio Pomponio

Abstract:

In this paper we deal with the following weakly coupled nonlinear Schrödinger system
$$\begin{cases} -\Delta_\alpha u + \omega u = |u|^2 u + \beta |v|^2 v & \text{in } \mathbb{R}^2, \\ -\Delta v + \tilde{\omega} v = |v|^2 v + \beta |u|^2 u & \text{in } \mathbb{R}^2, \end{cases}$$
 where $-\Delta_\alpha$ denotes the Laplacian operator with a point interaction, ω greater than a suitable positive constant, $\tilde{\omega} > 0$, and $\beta \geq 0$. For any $\beta \geq 0$ this system admits the existence of a ground state solution which can have only one nontrivial component or two nontrivial components and which could be regular or singular. We analyse this phenomenon showing how this depends strongly on the parameters.

Gradient trajectories from elastica to heterogeneous elastic curves with non-classical shapes

Schedule: July 9 8:30-9:00 Room 312

Masahiro Sakoda

Tohoku University, Japan

Co-Author(s): Shinya Okabe

Abstract:

In this talk, we will discuss planar closed elastic curves with density-modulated stiffness, which were inspired by experiments on biological membranes. In 2023, Brazda et al. characterized the heterogeneous elastic curves as the critical points of a geometric functional defined as the sum of a generalized bending energy with density-modulated stiffness and a Dirichlet energy for the density, under constraints on the total length and the total mass. Since any elastica with constant density is a trivial critical point in the model of density-dependent elastic curves, the functional can be regarded as a generalization of the classical bending energy. On the other hand, if the coefficient in the generalized elastic energy is non-smooth, the existence of heterogeneous elastic curves with non-classical shapes can be anticipated. The purpose of this talk is to prove (i) the existence of infinitely many heterogeneous closed elastic curves with non-classical shapes, and (ii) the existence of weak gradient trajectories connecting the classical elastica to the heterogeneous elastic curves obtained in (i). This talk is based on a joint work with Professor Shinya Okabe of Tohoku University.

Properties of radial steady states to flux-limited Keller-Segel systems

Schedule: July 9 15:00-15:30 Room 312

Takasi Senba

Kanagawa University, Japan

Abstract:

This talk is based on a joint work with Shohei Kohatsu (Tokyo University of Science). We consider radial solutions to lux-limited Keller-Segel systems with a parameter. If the parameter is bigger than the threshold, the system has blow-up solutions. If the parameter is less than the threshold, the system does not have blow-up solutions. Then, the parameter is closely related to properties of solutions. In this talk, we consider the relation between the parameter and properties of radial steady states.

Generalized Jacobi elliptic functions and their properties

Schedule: July 10 9:00-9:30 Room 312

Shingo Takeuchi

Shibaura Institute of Technology, Japan

Co-Author(s): Hajime Sato, Nagi Suzuki

Abstract:

Jacobi elliptic functions are natural extensions of trigonometric functions and play an important role in expressing exact solutions to certain semilinear ordinary differential equations. In this talk, we introduce a generalization of the Jacobi elliptic functions by replacing certain constants with three parameters (besides the modulus) and investigate their fundamental properties. This class of functions also extends the generalized trigonometric functions introduced by Dr`{a}bek and Man`{a}sevič, and is well suited for the study of certain quasilinear ordinary differential equations involving the p -Laplacian. We derive differential equations and integral formulas satisfied by the generalized Jacobi elliptic functions, together with binomial-type inequalities of Edmunds--Lang type. If time permits, we also discuss a generalization of Legendre's relation for their periods, namely, generalized complete elliptic integrals.

On Rayleigh quotients with a parameter for p -Laplace equations

Schedule: July 10 9:30-10:00 Room 312

Mieko Tanaka

Tokyo University of Science, Japan

Co-Author(s): Vladimir Bobkov

Abstract:

I'll talk about the Rayleigh quotients with a parameter for the p -Laplacian. It is well known that critical values of the standard Rayleigh quotient corresponds to eigenvalues for the p -Laplacian. I introduce that our quotient with a parameter also exhibits similar characteristics as a nonlinear eigenvalue problem. Moreover, I'd like to show that critical points correspond to solutions for p -Laplace equation with polynomial nonlinearities by converting it effectively.

The Lamé equation on the circle and applications to singular limite eigenvalue problems

Schedule: July 9 17:00-17:30 Room 312

Toru Wakasa

Kyushu Institute of Technology, Japan

Co-Author(s): Yasuhito Miyamoto, Kouichi Takemura

Abstract:

It is known that for the Lamé equation appears in the linearized eigenvalue problems associated with the solutions of nonlinear ODEs. The Lamé potential is expressed in the Jacobi sn-functions, and it is interesting to consider the case the modulus k is close to 1, from the viewpoint of singular limit problems. In this talk, we will show precise the asymptotic formula of all eigenvalues of Lamé equations as k to 1 under the periodic boundary condition. Moreover, the asymptotic results will be applied to several linearized eigenvalue problems.

Classification and evolution of bifurcation curves for the one-dimensional perturbed Gelfand problem with the Minkowski-curvature operator

Schedule: July 9 9:30-10:00 Room 312

Shin-Hwa Wang

National Tsing Hua University, TAIWAN, Taiwan

Co-Author(s): Shao-Yuan Huang

Abstract:

We study the classification and evolution of bifurcation curves of positive solutions for the one-dimensional perturbed Gelfand problem with the Minkowski-curvature operator

$$-\left(\frac{u'(x)}{\sqrt{1-(u'(x))^2}} \right)' = \lambda \exp \left(\frac{a}{a+u} \right) \text{ in } (0,1), \quad u(0)=u(1)=0$$

are evolution parameters. We determine the shapes of the bifurcation curves for different positive values a and L .

Stability of pinned p -elasticae

Schedule: July 9 18:30-19:00 Room 312

Kensuke Yoshizawa

Nagasaki University, Japan

Co-Author(s): Tatsuya Miura

Abstract:

Euler's elastica is a critical point of the bending energy under the fixed length constraint, and its L^p -counterpart is called p -elastica. In this talk, I will present a characterization of the stability of p -elasticae under the pinned boundary condition. The key ingredient is a new "cut-and-paste" method that does not rely on the second variation but instead exploits the geometric invariance of the functional. This talk is based on joint work with Tatsuya Miura (Kyoto University).

Special Session 157 : Advances in PDE-Based and Data-Driven Approaches for Applied Sciences

Organizer(s): Matteo Fornoni , Andrea Aspri , Cecilia Cavaterra

Introduction: This special session aims to highlight recent developments at the interface of mathematical modeling, inverse problems, and computational methods. The goal is to bring together researchers working on PDE-based models, both from a theoretical and numerical perspective, with those focusing on data-driven and learning-guided approaches, fostering connections and cross-fertilization of ideas. Possible applications span from biology and medicine, with the development of models and algorithms for tumor growth, to engineering, where the identification of defects in materials is of central importance, showing how hybrid approaches can advance the applied sciences.

Inverse and constrained optimization problems with applications to personalized medicine

Schedule: July 8 9:00-9:30 Room 434

Abramo Agosti

University of Pavia, Italy

Co-Author(s): Elena Beretta, Cecilia Cavaterra, Matteo Fornoni, Elisabetta Rocca

Abstract:

In this talk I will present different types of inverse and PDE-constrained optimization problems for multiphase tumour growth models which are of some interest for clinical applications. In particular, I will present the inverse identification problem of the initial condition from a single-point measurement at a final time for a Cahn-Hilliard type model describing tumour evolution in the a-vascular stage, and the parameters optimization problem for a multiphase model describing tumour growth in the vascular stage. I will show both analytical and numerical results, and present numerical simulations for both academic and patient-specific test cases.

On the reconstruction of early stages in tumour growth models

Schedule: July 8 13:30-14:00 Room 434

Elena Beretta

New York University Abu Dhabi, United Arab Emirates

Co-Author(s): Abramo Agosti Cecilia Cavaterra Matteo Fornoni Masahiro Yamamoto

Abstract:

We study backward inverse problems for coupled Cahn--Hilliard--reaction--diffusion systems. Our main result is a Carleman estimate for a fourth-order/second-order parabolic system with cross-diffusion terms. As a consequence, we derive conditional stability estimates for the reconstruction of past states from a single final-time observation: Hölder stability at positive times and logarithmic stability for the initial datum. We then apply the abstract theory to a phase-field tumour growth model coupling the tumour volume fraction with the nutrient concentration. In this setting, we obtain backward uniqueness and quantitative stability for the recovery of early tumour states, extending previous results and removing additional restrictions on the chemotactic coupling. We also discuss how these results support Lipschitz stability on finite-dimensional admissible sets, which is relevant for reconstruction algorithms.

Complete stickiness for nonlocal minimal graphs with obstacles in highly nonlocal regimes

Schedule: July 8 17:30-18:00 Room 434

Claudia D Bucur

University of Milan, Italy

Abstract:

We study the geometric and functional framework for a nonlocal Plateau problem with obstacles. In particular, we formulate the minimization of the fractional perimeter in cylinders with respect to graphical exterior data, as well as the equivalent variational problem for the nonlocal area functional. We then show that, when the prescribed exterior data is not too large at infinity and the fractional parameter is sufficiently small, minimizers exhibit complete stickiness: they adhere entirely to the obstacle and leave the remainder of the domain asymptotically empty.

PDE-constrained optimal control of viscous Cahn--Hilliard systems with hyperbolic relaxation

Schedule: July 8 9:30-10:00 Room 434

Pierluigi Colli

University of Pavia, Italy

Abstract:

Phase-field models such as the Cahn--Hilliard system play a central role in the PDE-based modeling of phase separation phenomena in applied sciences. In this talk, we investigate an optimal control problem for a viscous Cahn--Hilliard system in which the chemical potential is subject to a hyperbolic relaxation. We present recent analytical results for the associated state system, including well-posedness, regularity properties, and the Fréchet differentiability of the control-to-state mapping in suitable Banach spaces. Building on this framework, we study a sparse optimal control problem and derive first-order necessary conditions for local optimality. Finally, we analyze the asymptotic behavior of the system as the relaxation parameter tends to zero, providing convergence results for the state variables, optimal controls, and adjoint system.

A mathematical model of phase separation on biomembranes

Schedule: July 8 8:30-9:00 Room 434

Maurizio Grasselli

Politecnico di Milano, Italy

Co-Author(s): D. Caetano, C.M. Elliott, A. Poiatti

Abstract:

We present a model for phase separation of multiple components on a biological membrane, allowing for small deformations of a spherical shape. The model couples a multi-component Cahn--Hilliard equation with an equation for the membrane geometry, derived using variational principles. We show that the system is well posed and that solutions become regular over time, staying away from pure phases. Moreover, every solution eventually converges to a single equilibrium configuration.

An inverse problem for the Monge-Ampere equation

Schedule: July 8 15:00-15:30 Room 434

Yi-Hsuan Lin

National Yang Ming Chiao Tung University, Taiwan

Co-Author(s): Tony Liimatainen

Abstract:

We extend the study of inverse boundary value problems to the setting of fully nonlinear PDEs by considering an inverse source problem for the Monge--Amp\`ere equation

$$\det D^2 u = F.$$

We prove that, on a convex Euclidean domain in the plane, the associated Dirichlet-to-Neumann (DN) map uniquely determines a positive source function F . The proof relies on recovering the Hessian of a solution to the equation, which is interpreted as a Riemannian metric g . Interestingly, although the equation is posed on a Euclidean domain, the inverse problem becomes anisotropic since the metric g appears as a coefficient matrix in the linearized equation. As an intermediate step, we prove that the DN map of the non-divergence form equation

$$g^{ab} \partial_{ab} v = 0$$

uniquely determines the conformal class of the metric g on a simply connected planar domain, without the usual diffeomorphism invariance. To address the challenges of full nonlinearity, we develop asymptotic expansions for complex geometric optics solutions in the planar setting and solve a resulting nonlocal op -equation by proving a unique continuation principle for it. These techniques are expected to be applicable to a wide range of inverse problems for nonlinear equations.

Enhanced dissipation and applications to non-linear PDEs

Schedule: July 8 16:30-17:00 Room 434

Anna L Mazzucato

Penn State University, USA

Abstract:

I will discuss recent results concerning enhanced dissipation in drift-diffusion equations by the action of the drift. If time permits I will then give an application to global existence for the 2D Kuramoto-Sivashinsky equation, a model of front propagation in combustion. Enhanced dissipation has applications in speeding up Langevin dynamics and MCMC methods.

Convergence to equilibrium of weak solutions to the Cahn--Hilliard equation with non-degenerate mobility: a novel perspective

Schedule: July 8 8:00-8:30 Room 434

Andrea Poiatti

University of Parma, Italy

Co-Author(s): Maurizio Grasselli

Abstract:

We consider the initial and boundary value problem for the Cahn--Hilliard equation with non-degenerate mobility and singular potential. We show that any weak solution converges to a single equilibrium using only minimal assumptions, i.e., the existence of a global weak solution satisfying an energy inequality. This result also holds in the three-dimensional case, which was an open problem so far due to the lack of regularity of solutions, especially when the mobility is just a continuous function. This novel method is robust and can be used also for other models like, for instance, Cahn--Hilliard-Navier--Stokes type systems with unmatched densities and viscosities as the one proposed by Abels, Garcke, and Grün (Math. Models Methods Appl. Sci. 22, 2012).

The Calderón problem with random measurements

Schedule: July 8 14:00-14:30 Room 434

Simone Sanna

University of Genoa, Italy

Co-Author(s): Giovanni S. Alberti, Damiano Poletti, Matteo Santacesaria

Abstract:

The Calderón problem consists in recovering an unknown parameter of a partial differential equation from boundary measurements of its solution. While global uniqueness is well-established for the full Dirichlet-to-Neumann operator, corresponding to infinitely many boundary measurements, practical applications, such as EIT, operate with finite and discrete data. In this realistic setting, the unknown parameter is assumed to lie in a finite-dimensional space, and the boundary data are restricted to a finite family of Dirichlet-Neumann pairs. This reduction leads to a fundamental question regarding sample complexity: what is the minimal number of measurements M required to reconstruct a d -dimensional unknown? Due to the non-linearity and severe ill-posedness of the problem, existing deterministic results often yield sample complexity estimates that are exponential in d . In this work, we address this question using randomized boundary data. Instead of deterministically choosing a finite number of boundary data from a fixed orthonormal basis on the boundary of the domain, we take random linear combinations of such basis elements. We prove that this approach ensures almost sure uniqueness with a number of measurements M that is merely proportional to the dimension of the parameter space d , significantly improving upon current deterministic bounds.

Neural network parametrized level sets for image segmentation

Schedule: July 8 15:30-16:00 Room 434

Cong Shi

University of Vienna, Austria

Co-Author(s): Otmar Scherzer and Thi Lan Nhi Vu

Abstract:

The Chan-Vese functionals have proven to be a first-class method for segmentation and classification. Previously they have been implemented with level-set methods based on a pixel-wise representation of the level-sets. Later parametrized level-set approximations, such as splines, have been studied. In this talk we consider neural networks as parametrized approximations of level-set functions. We show in particular, that parametrized two-layer networks are most efficient to approximate polyhedral segments and classes. We also prove the efficiency for segmentation and classification.

Recovery of an Anisotropic Conductivity from the Neumann-to-Dirichlet Map in a Semilinear Elliptic Equation

Schedule: July 8 14:30-15:00 Room 434

Eva Sincich

University of Trieste, Italy

Co-Author(s): Elena Beretta, Elisa Francini, Dario Pierotti

Abstract:

We study the inverse boundary value problem of detecting a non-uniform conductivity motivated by pacing-guided ablation in cardiac electrophysiology. At the stationary level, the transmembrane potential u in a region $\Omega \subset \mathbb{R}^3$ of cardiac tissue satisfies

$$-\nabla \cdot (\gamma \nabla u) + \alpha u^3 = 0 \quad \text{in } \Omega, \quad \gamma \nabla u \cdot \nu = g \quad \text{on } \partial\Omega,$$

where γ is an anisotropic conductivity tensor and α a nonlinear ionic response coefficient. The Neumann data g represent pacing currents, and the boundary values $u|_{\partial\Omega}$ correspond to invasive voltage measurements. Ischemic regions are modeled by a subdomain $D \subset \Omega$ where γ is piecewise constant. We address the inverse problem of determining γ from the Neumann-to-Dirichlet (NtD) map, assuming that α and D are known.

Curvature-driven pattern formation in biomembranes: A gradient flow approach

Schedule: July 8 17:00-17:30 Room 434

Dennis Trautwein

University of Regensburg, Germany

Co-Author(s): Patrik Knopf, Anastasija Pe\v{s}i\v{c}

Abstract:

In this talk, we study a phase-field model for curvature-driven pattern formation in biomembranes. The model is derived as a gradient flow of an energy functional that approximates the two-phase Canham--Helfrich energy. This leads to a Cahn--Hilliard-type equation with cross diffusion for the relative chemical concentration of one lipid phase, coupled to a fourth-order reaction-diffusion equation describing the height profile of the membrane. We first prove the existence of weak solutions for the case of regular double-well potentials, using a minimizing movement scheme to construct approximate solutions. The analysis is then extended to singular potentials, e.g., the Flory--Huggins potential, by approximating them with a Moreau--Yosida regularization. For both cases, we establish higher regularity, continuous dependence on the initial data, and consequently the uniqueness of weak solutions. Finally, we propose a well-posed finite element discretization of the model and present numerical experiments illustrating the effect of different physical parameters on the resulting membrane patterns. Depending on the parameter regime, we observe purely striped, dotted, or snake-like structures.

Special Session 158 : From PDE control to the qualitative study of (random) dynamical systems

Organizer(s): Manuel Rissel , Vahagn Nersesyan , Marius Tucsnak

Introduction: This special session is devoted to recent challenges and advances in the study of chaotic behavior and mixing phenomena in complex physical systems such as those describing fluid flows, particles, or waves. Of particular interest are systems driven by degenerate noise, systems where randomness enters through a lower dimensional spatial component such as those described by PDEs with boundary noise, or systems which may exhibit singularities. In this context, control theoretic arguments increasingly play an important technical role, while being also of remarkable independent interest. The scope of this session is not limited to random dynamics; for instance, one could think about the question how well a given deterministic flow mixes an immersed concentration, or whether such a process could be externally controlled in a satisfactory manner. The general goal is to learn about different perspectives on these interconnected topics and to jointly explore possible steps towards a better mathematical understanding of complex nonlinear systems.

Feedback stabilization of entropy solutions to the p-system at a junction

Schedule: July 9 9:30-10:00 Room 812

Nicola De Nitti

University of Pisa, Italy

Co-Author(s): G. M. Coclite, N. De Nitti, M. Garavello, F. Marcellini

Abstract:

We consider the p-system in Eulerian coordinates on a star-shaped network. Under suitable transmission conditions at the junction and dissipative boundary conditions in the exterior vertices, we show that the entropy solutions of the system are exponentially stabilizable. Our proof extends the strategy by Coron et al. (2017) and is based on a front-tracking algorithm used to construct approximate piecewise constant solutions whose BV norms are controlled through a suitable exponentially-weighted Glimm-type Lyapunov functional.

Differentiability of transition semigroup of generalized Ornstein-Uhlenbeck process

Schedule: July 8 14:30-15:00 Room 812

Ben Goldys

Sydney University, Australia

Co-Author(s): Szymon Peszat

Abstract:

Let X be a Banach space-valued Ornstein-Uhlenbeck process driven by a possibly degenerate Brownian Motion and let P_t stand for the transition operator of the process. We provide a simple probabilistic proof of the fact that null-controllability of the corresponding deterministic system implies infinite Fréchet differentiability of $P_t f$ for every bounded Borel function f . Moreover, using the Girsanov theorem we provide a pointwise formula for all the derivatives of $P_t f$ in terms of multiple stochastic integrals. Applications to the analysis of transition semigroups in finite and infinite dimensions are given. In particular we consider the heat equation with space-time white noise boundary conditions.

On the controllability of the semi-geostrophic equation. Part II

Schedule: July 8 17:00-17:30 Room 812

Vincent Laheurte

Université du Luxembourg, Luxembourg

Abstract:

Following the first part of this talk by Franck Sueur, I will present some controllability issues for the two-dimensional dual semi-geostrophic equation, a fully nonlinear counterpart of the incompressible Euler equations, where the linear Biot-Savart law is replaced by the nonlinear Monge-Ampère equation. For solutions near the equilibrium state, and through a long-time rescaling, one may establish a connection with the Euler equations. By exploiting this link, I will describe how to recover controllability results (Lagrangian and Eulerian) for the dual semi-geostrophic equation.

Robust control of linear systems under small parameter variation

Schedule: July 9 9:00-9:30 Room 812

Pierre Lissy

CERMICS, Ecole nationales des ponts et chaussées, France

Co-Author(s): Sylvain Ervedoza and Yannick Privat

Abstract:

In this talk, I will discuss insensitization problems for linear controlled evolutions under small parameter variations. The goal is to design a control which both drives the nominal system to a prescribed target and cancels the first-order sensitivity of the final state with respect to the parameter. I will present an abstract framework, in which this question is recast as a controllability problem for a coupled state-sensitivity cascade system. In finite dimension, I will give a complete characterization in terms of a Kalman-type rank condition. I will also illustrate the approach on PDE examples, including the heat equation with uncertain diffusion and the wave equation with uncertain potential.

Sensitivity analysis of colored-noise-driven interacting particle systems

Schedule: July 8 15:00-15:30 Room 812

Laurent Mertz

City University of Hong Kong, Hong Kong

Co-Author(s): Josselin Garnier, Harry Ip

Abstract:

We propose an efficient sensitivity analysis framework for a broad class of interacting particle systems driven by colored noise. The method relies on unperturbed simulations and substantially extends the Malliavin weight sampling approach introduced by Szamel for systems driven by Ornstein--Uhlenbeck noise. It enables the computation of sensitivity indices, including linear response functions, in settings with general colored noise. We show that these sensitivities depend not only on effective quantities such as the noise variance and correlation time, but also explicitly on the full noise spectrum. For a single particle in a harmonic potential, we derive exact analytical expressions for two classes of linear response functions. We then apply the method to a many-particle system interacting through a repulsive screened Coulomb potential, where we compute transport properties such as mobility and effective temperature. Our results demonstrate that dynamical behavior depends on the spectral properties of the driving noise in a nontrivial manner.

Controllability as a key tool for studying long-time behaviour of random dynamical systems

Schedule: July 8 9:00-9:30 Room 812

Vahagn Nersesyan

NYU Shanghai, Peoples Rep of China

Abstract:

This talk is devoted to the study of the long-time behaviour of random dynamical systems under highly degenerate non-Gaussian forcing. I will review recent results showing how controllability properties of the underlying deterministic dynamics can be used to handle the degeneracy and establish ergodic behaviour.

Stability of a KdV equation close to critical lengths

Schedule: July 9 8:30-9:00 Room 812

Jingrui Niu

Institute for Advanced Study in Mathematics, Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Shengquan Xiang

Abstract:

In this talk, we study the quantitative exponential stability of the KdV equation on a finite interval, focusing on the cases where the length is close to the critical set. Through a constructive PDE control framework, we obtain sharp decay estimates for such cases. Specifically, I will introduce a transition-stabilization approach that combines the Lebeau--Robbiano strategy with the moment method to establish quantitative null controllability for the KdV equation. Furthermore, based on a classification of these critical lengths, we show that the KdV equation exhibits different asymptotic behaviors near different types of critical lengths. This is a joint work with Shengquan Xiang.

Controllability of incompressible fluids and related systems driven by degenerate forcing

Schedule: July 9 8:00-8:30 Room 812

Manuel Rissel

ShanghaiTech University, Peoples Rep of China

Abstract:

I will talk about global controllability properties of incompressible fluids and related models driven by degenerate forcing, that is, by controls acting only in few equations of the considered systems or by controls that have a particular finite-dimensional structure.

On the controllability of the semi-geostrophic equation. Part I

Schedule: July 8 16:30-17:00 Room 812

Franck Sueur

University of Luxembourg, France

Abstract:

In the first part of this two-parts talk (second part would be done by Vincent Laheurte), I will present some controllability issues for the two-dimensional dual semi-geostrophic equation, a fully nonlinear counterpart of the incompressible Euler equations, where the linear Biot-Savart law is replaced by the nonlinear Monge-Ampère equation.

Holomorphic regularity of processes generated by the heat equation with white noise boundary data

Schedule: July 8 14:00-14:30 Room 812

Marius Tucsnak

University of Bordeaux, France

Abstract:

We consider the heat equation on a bounded interval with Dirichlet or Neumann boundary conditions driven by independent white noises at the endpoints. Although boundary white-noise forcing is usually associated with very low regularity, we show that the corresponding stochastic evolution in fact exhibits a sharp holomorphic regularity. More precisely, for every positive time the solution extends holomorphically to a rhombus in the complex plane having the original interval as one of its diagonals, and the resulting process admits a continuous version with values in a scale of weighted Bergman spaces on that domain. We determine the precise range of parameters for which this phenomenon holds, indexed by the parameters $\delta \in (0, 1)$ and $\Theta \in (0, \frac{\pi}{4})$, and prove that it is optimal: the conclusion fails at the critical values $\delta = 0$ and $\Theta = \frac{\pi}{4}$. Our approach combines recent advances on reachability theory for boundary-controlled systems with techniques from Bergman-space theory. In this way, we extend to the stochastic setting the sharp regularity of time continuous trajectories recently developed for deterministic heat equations.

Symmetry and observability for wave equations on the torus

Schedule: July 8 15:30-16:00 Room 812

Shengquan Xiang

Peking University, Peoples Rep of China

Abstract:

In this talk, I will discuss observability for wave equations, with particular emphasis on symmetry. I will focus on spacetime measurable observation sets on the one-dimensional torus, where a complete characterization is available. I will first describe a counterexample showing that the Geometric Control Condition (GCC), while sufficient in many settings, does not guarantee observability when observation is restricted to certain spacetime measurable sets. Inspired by this counterexample, we introduce a symmetry condition, referred to as the Observable Symmetry Condition (OSC), which captures an additional structural constraint underlying observability. We show that OSC, together with GCC, provides a necessary and sufficient characterization of observability on spacetime measurable sets. Finally, motivated by OSC, we introduce a weak GCC and show that, when combined with OSC, it yields a necessary and sufficient condition for unique continuation.

Global Exponential Stabilization for a Simplified Fluid-Particle Interaction System

Schedule: July 8 17:30-18:00 Room 812

Zhuo XU

University of Bordeaux, France

Co-Author(s): Marius Tucsnak

Abstract:

In this talk, we present a stabilization result for a simplified one-dimensional fluid-particle interaction system. First, without any smallness assumptions, we establish a non-collision property: the particle never reaches the fluid boundary in finite time, which in turn yields global well-posedness of the interaction system. Next, we study a stabilization problem for this model. In the absence of feedback control, the particle converges to an *a priori* unknown limit position h^* that cannot be described solely by the initial data. To regulate the final position of the particle to an arbitrary target $h_1 \in (-1, 1)$, we employ a proportional feedback control acting on the particle, $u(t) = K(h_1 - h(t))$, $K > 0$, and prove that both the position error $h(t) - h_1$ and the total kinetic energy of the closed-loop system decay exponentially to zero.

Continuous energy solutions to 3D (stochastic) Navier-Stokes and MHD equations

Schedule: July 8 9:30-10:00 Room 812

Deng Zhang

Shanghai Jiao Tong University, Peoples Rep of China

Co-Author(s): Deng Zhang

Abstract:

In this talk we will show that for arbitrarily prescribed finite energy divergence-free initial data, there exist infinitely many global-in-time weak solutions with continuous energy profiles to both the 3D deterministic and stochastic Navier-Stokes equations. When the initial data is in $H^1/2$, we prove the existence of infinitely many dissipative solutions to the 3D Navier-Stokes and MHD equations, whose energy profiles are continuous and decreasing on time. Our proof introduces a new backward convex integration scheme that takes advantage of the dissipative term.

Special Session 159 : New Developments in Open-Source Software for Inverse Problems

Organizer(s): Evangelos Papoutsellis , Ander Biguri

Introduction: Open-source software has had a profound impact on both industry and academia over the past 50 years, revolutionising how we develop, share, and collaborate on software solutions. Within the sphere of inverse problems, it has enabled access to many modalities of practical importance— including medical, chemical, and seismic imaging; materials science; and more. This special session aims to showcase new developments in open-source software for inverse problems and to foster collaboration across disciplines. We will highlight theory, algorithms, and applications that advance reproducible imaging pipelines—from regularisation techniques and variational models to large-scale optimisation and hybrid model-driven/data-driven approaches. Talks will demonstrate end-to-end, FAIR, and well-documented toolchains that enable trustworthy reconstruction and analysis across modalities such as CT, PET, and MRI; chemical and spectral imaging; seismic exploration; and materials characterisation. By bringing together software developers, applied mathematicians, and domain scientists, the session aims to lower barriers to entry, disseminate practical tools, address challenges of scalability and generalisation, and accelerate the translation of methods into robust, real-world imaging systems.

The TIGRE and LION toolboxes for algorithms in applied tomographic reconstruction

Schedule: July 9 8:30-9:00 Room 823

Ander Biguri

University of Cambridge, England

Co-Author(s): Ander Biguri

Abstract:

TIGRE (Tomographic Iterative GPU-based Reconstruction Toolbox) and LION (Learning-based Iterative Optimized Networks) are two advanced software toolboxes designed for applied computed tomography (CT) reconstruction, each reflecting a different paradigm in modern imaging. TIGRE Toolbox is an open-source, GPU-accelerated platform developed to support fast and flexible implementation of iterative reconstruction algorithms, particularly for cone-beam CT. It provides a wide range of analytical and iterative methods, enabling researchers to model system geometry accurately and experiment with techniques such as total variation minimization and algebraic reconstruction. Its emphasis on computational efficiency makes it well suited for large-scale 3D problems and real-time applications. In contrast, LION Toolbox focuses on integrating deep learning into the reconstruction pipeline. It enables the design and training of neural networks that mimic or enhance iterative algorithms, often leading to improved image quality and reduced reconstruction time. LION supports hybrid approaches that combine model-based physics with data-driven learning, making it particularly relevant for low-dose and sparse-view CT scenarios. Together, TIGRE and LION illustrate the convergence of classical optimization and modern machine learning, providing complementary tools for advancing research and practical applications in CT reconstruction.

An Advanced Toolbox for Multitask Medical Imaging Consistency (ATOMMIC)

Schedule: July 9 9:00-9:30 Room 823

Dimitris Karkaloulos

Amsterdam University Medical Centers, Netherlands

Co-Author(s): Dimitris Karkaloulos, Ivana Isgum, Henk A. Marquering, Matthan W.A. Caan

Abstract:

The inverse problem of accelerated Magnetic Resonance Imaging (MRI) reconstruction can be solved through Bayesian estimation, where high-quality images are recovered from undersampled measurements in the frequency domain (k-space). Deep learning has driven remarkable progress through iterative optimization schemes, effectively solving the inverse problem end-to-end from acquisition to analysis. Downstream analysis tasks such as quantitative parameter map estimation and segmentation depend directly on reconstruction quality, coupling inverse and inference problems. Existing frameworks typically address these tasks independently, breaking the acquisition and analysis chain and limiting generalization. We present the Advanced Toolbox for Multitask Medical Imaging Consistency (ATOMMIC), an open-source toolbox that unifies AI-driven MRI reconstruction and analysis by natively supporting multitask learning. ATOMMIC enables end-to-end optimization from k-space to task-specific outputs by implementing over 25 deep learning models with harmonized complex-valued and real-valued data support, standardized workflows, and diverse undersampling schemes. Extensive reproducible benchmarks across eight public datasets demonstrate that physics-based models excel at highly accelerated reconstruction and that multitask learning consistently improves performance on both reconstruction and downstream tasks compared to sequential single-task approaches. ATOMMIC provides a comprehensive framework for integrating and evaluating datasets, models, and tasks, and is open-sourced under Apache 2.0 license at <https://github.com/wdika/atommic>.

MRpro-An open PyTorch-based MR reconstruction and processing package

Schedule: July 9 9:30-10:00 Room 823

Andreas Kofler

Physikalisch-Technische Bundesanstalt (PTB), Braunschweig and Berlin, Germany

Co-Author(s): Andreas Kofler

Abstract:

We present MRpro, an open-source image reconstruction package for MRI built upon PyTorch and open data formats. MRpro consists of three main areas. First, it provides unified datastructures for the processing and handling of MR datasets and their associated metadata, such as sampling trajectories in the Fourier domain. Second, it provides relevant mathematical concepts and operations required to build abstract reconstruction algorithms. Third, to enable the easy development of state-of-the-art learned reconstruction methods, MRpro includes essential building blocks such as so-called data-consistency layers, differentiable optimization layers and well-established neural network backbones. In this talk, we showcase different components of MRpro by considering several learned and non-learned MR imaging problems using both publicly available open-source data, numerical phantoms as well as raw scanner data, demonstrating MRpro's versatility.

Benchmarking Large Scale Inverse Problems Resolution Algorithms with Benchopt

Schedule: July 9 15:00-15:30 Room 823

Benoit Malezieux

CNRS, France

Abstract:

Many scientific domains, including 3D tomography and radio astronomy, rely on solving large-scale imaging inverse problems, where a single data sample can reach sizes of 100 million to 1 billion pixels, making both computation and memory critical challenges. This talk introduces a benchmarking framework, built on Benchopt, designed to evaluate the scalability of modern inverse problem solvers on HPC systems. We focus in particular on recent deep learning-based approaches, such as Plug-and-Play methods. The benchmark enables controlled comparisons of reconstruction quality, runtime, and memory usage as computational resources are scaled across distributed architectures. Beyond performance evaluation, this work aims to establish a common ground between methodological innovation and large-scale scientific applications, enabling the development of algorithms that are not only accurate, but also scalable and practically deployable in real-world HPC settings.

The Core Imaging Library: Modular Optimisation for Imaging Inverse Problems

Schedule: July 9 13:30-14:00 Room 823

Evangelos Papoutsellis

Finden Ltd, University of Manchester, England

Abstract:

The Core Imaging Library (CIL) is an open-source Python framework for solving imaging inverse problems, with a particular emphasis on tomography modalities such as X-ray CT, MRI, and PET. CIL supports multiple stages of the imaging workflow, including data reading, preprocessing, reconstruction and visualisation, making it a versatile platform for developing and testing advanced imaging methods. A central strength of CIL is its modular optimisation framework, which enables users to combine operators, data fidelity terms, and regularisation functionals to formulate and solve a wide range of smooth and non-smooth optimisation problems using first-order methods. Recent developments further extend these capabilities through a flexible stochastic optimisation framework, allowing researchers to configure and test different algorithmic building blocks, sampling strategies, and step-size rules. In this talk, I will introduce CIL, outline its role across the imaging pipeline, and highlight in particular its optimisation module, together with examples from real-world imaging applications that demonstrate its value for developing, testing, and benchmarking advanced methods for inverse problems.

Inversion of Operator Pipelines with Well-Specified Spaces and Backend Heterogeneity

Schedule: July 9 14:00-14:30 Room 823

Justus Sagemüller

KTH Royal Institute of Technology, Sweden

Co-Author(s): Emilien Valat, Ozan Oktmen, Joakim Andén

Abstract:

The forward mapping for an inverse problem is often best understood in terms of mathematical transformations between certain function spaces. The inversion meanwhile is typically performed with iterative algorithms, looping over calls through a pipeline of operators. This involves arrays as the interchange data type. While arrays are structurally simple, they lack mathematical context and can be ambiguous. Furthermore, one operator may prefer to store its arrays on a GPU, another may only have a CPU implementation, or there may not be enough memory on a single GPU for the entire data size. Working around such limitations requires conversion and copying, which remains bug-prone and detrimental to performance even with help from utilities like DLPack and the Python Array API. The ODL framework wraps arrays into more informative abstractions. This makes it easier to organize code and get it to work correctly. In recent work, we have made these abstractions also capable of tracking different Python libraries for array storage and processing. This gives better control over if and where transfer between backends happens, as well as allowing multiple different devices to simultaneously store parts of the data.

DeepInverse: A Python package for solving imaging inverse problems with deep learning

Schedule: July 9 14:30-15:00 Room 823

Jeremy Scanvic

LPENSL, France, France

Abstract:

DeepInverse is an open-source PyTorch-based library for imaging inverse problems. DeepInverse implements all steps for image reconstruction, including efficient forward operators, defining and solving variational problems and designing and training advanced neural networks, for a wide set of domains (medical imaging, astronomical imaging, remote sensing, computational photography, compressed sensing and more).

Evolving the ASTRA Toolbox: Computed Tomography in the Age of Deep Learning

Schedule: July 9 16:30-17:00 Room 823

Alexander Skorikov

CWI Amsterdam, Netherlands

Co-Author(s): Alexander Skorikov, Willem Jan Palenstijn

Abstract:

The ASTRA Toolbox provides a set of flexible and efficient GPU primitives for transmission-based tomography. It has been powering multiple use cases and software libraries for almost 20 years already, while being continuously maintained, expanded and adapted to the changing demands in the field. One of the important and recent factors for the development of the ASTRA Toolbox has been the tremendously fast growth of Deep Learning adoption in many scientific and engineering applications. In this talk, I will outline what we have been doing to facilitate using the toolbox in combination with Deep Learning libraries and systems, and will provide our outlook for the future direction of its development.

nDTomo: A Python library for X-ray Chemical Imaging and Computed Tomography

Schedule: July 9 17:00-17:30 Room 823

Antony Vamvakeros

Imperial College London, England

Co-Author(s): Antonis Vamvakeros, Evangelos Papoutsellis, Hongyang Dong, Ronan Docherty, Andrew M. Beale, Samuel J. Cooper, Simon D.M. Jacques

Abstract:

X-ray chemical imaging techniques, such as XRD-CT, provide vital spatially-resolved information for materials science, yet data processing remains computationally demanding. We present nDTomo, an open-source Python toolkit designed for the simulation, reconstruction, and analysis of hyperspectral tomographic data. Unlike highly abstracted frameworks, nDTomo emphasises pedagogical clarity through a function-centric design, making it ideal for both research and education. The suite integrates standard reconstruction algorithms with deep learning capabilities, including the self-supervised PeakFitCNN for automated peak analysis and GPU-accelerated direct least squares reconstruction (DLSR). We demonstrate the utility of the toolkit through its application in battery research and catalysis, highlighting its ability to correct experimental artifacts such as motor jitter and beam decay. By combining an intuitive PyQt-based graphical user interface (nDTomoGUI) with a modular backend and interactive Jupyter notebooks, nDTomo provides a transparent and reproducible environment for chemical imaging workflows.

OMEGA - Open-source multi-dimensional tomographic reconstruction software for MATLAB, GNU Octave and Python

Schedule: July 9 17:30-18:00 Room 823

Ville-Veikko Wettenhovi

University of Eastern Finland, Finland

Co-Author(s): Niilo Saarlemo

Abstract:

In this talk, we present OMEGA - Open-source multi-dimensional tomographic reconstruction software, available for MATLAB, GNU Octave and Python. OMEGA is designed for easy and efficient GPU-based reconstruction of computed tomography (CT), positron emission tomography (PET) and single photon emission computed tomography (SPECT) data, with support for any type of data that uses similar ray-tracing approaches. OMEGA includes dozens of built in algorithms and regularization methods, as well as the ability to perform forward projection (Ax) and backprojection ($A^T y$) operations on any data, in both MATLAB/Octave and Python environments. Unlike other software, OMEGA supports OpenCL, in addition to CUDA, for GPU computations and thus works with any hardware, including CPUs. OMEGA also includes preliminary support for Apple Metal for Mac support. In Python, the forward and backward projections allow interoperability with CuPy, PyTorch, PyOpenCL and ArrayFire data. OMEGA additionally includes several optional features, such as attenuation correction for PET and SPECT, normalization correction for PET, several different projectors for computing the forward and backward projections, methods to prevent out-of-field of view artifacts in CT, several preconditioners, and more. For more information on the software, see the GitHub page: <https://github.com/villekf/OMEGA>.

Special Session 160 : Recent progress on stochastic analysis and stochastic control with applications

Organizer(s): Chao Zhu

Introduction: This session will bring together researchers working at the intersection of stochastic analysis, control theory, and their diverse applications. Recent years have witnessed major advances in the study of complex stochastic systems, such as regime-switching diffusions with law and path dependence, whose asymptotic properties reveal novel aspects of long-term behavior. Parallel progress in stochastic control methods, particularly those incorporating mean-field interactions, has provided powerful tools for optimizing large populations of interacting agents. These theoretical developments have broad applicability across numerous fields: in mathematical finance for modeling systemic risk and trading frictions; in mathematical biology for analyzing population dynamics subject to abrupt interventions; in risk management for quantifying and mitigating uncertainty; in natural resource management for designing sustainable harvesting policies in stochastic environments; and in inventory control for optimizing decisions under volatile supply and demand. By highlighting these advances, the session will deepen our understanding of stochastic systems and stochastic control techniques, stimulate disciplinary and interdisciplinary collaborations, and identify promising new directions for future research.

An Asymptotic Expansion of the Profit Function of a Class of Impulse Control Problems

Schedule: July 8 17:00-17:30 Room 436

Kurt L Helmes

Humboldt Universitaet zu Berlin, Germany

Abstract:

We derive an explicit asymptotic expansion for the profit function in a class of long-term average stochastic impulse control problems for one-dimensional diffusions with two revenue streams: intervention rewards and state-dependent subsidies. Optimality results characterize the long-term average optimal value F^* as the maximum of a nonlinear function on $\mathbb{R}^2$ and the optimal threshold policy as its argmax. When the diffusion's left boundary is an entrance point, the profit function $J^*(T, x)$, representing the expected accumulated optimal profit up to time T , satisfies $J^*(T, x) \approx F^*T + G(x) - \langle G, \nu^* \rangle$, where ν^* is the stationary distribution of the optimally controlled system and G the relative value function. The correction term $G(x) - \langle G, \nu^* \rangle$ can also be expressed using the first two moments of the profit contributions and the average cycle time of the optimal process. This interpretable representation aids applications and reveals connections to cumulative renewal processes. The results are joint work with R. Stockbridge and C. Zhu and are based on Long-Term Average Impulse and Singular Control of a Growth Model with Two Revenue Sources (2026a, <https://arxiv.org/pdf/2601.09646.pdf>) and Long-Term Average Impulse Control with Mean Field Interactions (2026b, <https://arxiv.org/pdf/2505.11345.pdf>).

Large deviation principles for fully coupled multiscale multivalued stochastic systems

Schedule: July 8 13:30-14:00 Room 436

Huijie Qiao

Southeast University, Peoples Rep of China

Abstract:

This study focuses on large deviation principles for fully coupled multiscale multivalued stochastic systems, in which the slow component is governed by a multivalued stochastic differential equation and the fast component is described by a general stochastic differential equation. First, we establish the large deviation principle for the slow component at any fixed time by leveraging viscosity solutions of second-order Hamilton-Jacobi-Bellman equations involving multivalued operators. Subsequently, we illustrate the theoretical results through a concrete finance example.

Averaging Principle for Fully Coupled Two-Time-Scale Stochastic Systems with Infinite Integral-Type Delays and Application to Near-Optimal Control

Schedule: July 8 14:30-15:00 Room 436

Meilin Tang

Department of Mathematics Huazhong University of Science and Technology, Peoples Rep of China

Co-Author(s): Fuke Wu

Abstract:

This paper establishes the averaging principle for a class of fully coupled two-time-scale stochastic functional differential equations involving infinite integral-type delays with exponential kernels. The presence of delays leads to the lack of the Markov property, which introduces essential difficulties. Noting the special structure of the infinite delay, by using the variable substitution technique, this paper transforms the original system into a higher-dimensional system without delay. For this higher-dimensional system, we establish the existence and uniqueness of the invariant probability measure for the fixed- X equation and continuous dependence on the parameter X . Moreover, the uniform moment boundedness of the fast-varying and slow-varying variables is also proved. Based on these results, by using the martingale problem formulation, we prove the weak convergence of the slow-varying process. As an important application, we investigate a two-time-scale stochastic optimal control problem. By using the established averaging principle and the relaxed control framework, we prove the convergence of the value function and construct near-optimal controls for the original system by using the optimal control of the limit problem. Finally, the example of an optimal advertising problem is presented to demonstrate the applicability of the obtained results.

Minimizing the Ruin Probability with Irreversible Reinsurance and Investments

Schedule: July 8 8:30-9:00 Room 436

Gu Wang

Worcester Polytechnic Institute, USA

Abstract:

The insurer chooses the investment and reinsurance strategy to minimize the probability of ruin, in a diffusion model for the uncontrolled surplus. The reinsurance contract is irreversible and costly with transaction cost at purchase and premium proportional to the size of ceded risk. The optimal strategy entails constant dollar amount invested in the financial asset correlated with the actuarial risk and reinsurance purchase only when the surplus is greater than the endogenous free boundary. For sufficiently large level of ceded risk, reinsurance becomes ineffective for reducing ruin probability due to the long term premium commitment

Recent progress on optimal control of partially observable forward-backward stochastic system

Schedule: July 8 9:30-10:00 Room 436

Guangchen Wang

Shandong University, Peoples Rep of China

Abstract:

This talk is concerned with recent progress on optimal control of forward-backward stochastic system, where the information available to controller is provided by noisy observation. A backward separation method is originally proposed and is used to establish a fundamental research framework for such a class of problems. The framework is also applicable to other important scenarios.

Fast-Slow Coupled Forward-Backward Stochastic Differential Equations

Schedule: July 8 14:00-14:30 Room 436

Fuke Wu

Huazhong University of Science and Technology, Peoples Rep of China

Co-Author(s): Yihao Sheng, George Yin

Abstract:

This work focuses on fast-slow coupled forward-backward stochastic differential equations (FBSDEs). Firstly, the well-posedness of such systems is established and some necessary estimates are provided. Subsequently, the averaging principle with strong convergence for both forward and backward components is established by using Khasminskii's time discretization technique. Finally, this averaging principle is applied to examine the singularly perturbed linear-quadratic stochastic control problem.

Averaging principles for nonautonomous multiscale McKean-Vlasov stochastic systems

Schedule: July 8 15:00-15:30 Room 436

Jie Xiang

School of Mathematics, Southeast University, Peoples Rep of China

Co-Author(s): Huijie Qiao

Abstract:

In this paper, we study a class of nonautonomous multiscale McKean-Vlasov stochastic systems. By using the nonautonomous Poisson equation, we establish the strong and weak averaging principles with explicit convergence rates. In general, the coefficients of the averaged equations depend on the scaling parameter ε . Additionally, when the fast coefficients are asymptotically convergent or time-periodic, we show that the slow component converges, in the strong and weak senses, to the solution of an averaged equation with coefficients independent of ε .

Pairs Trading under Geomertic Brownian Motions

Schedule: July 8 9:00-9:30 Room 436

Qing Zhang

University of Georgia, USA

Abstract:

This talk studies optimal strategies for pairs trading, in which a long position is taken in a weaker stock and a short position in a stronger one following price divergence. Stock prices are modeled by general geometric Brownian motions, and transaction costs are incorporated. The optimal trading policy is characterized by threshold curves derived from Hamilton Jacobi Bellman equations. Several recent developments are also reported, including pairs trading with stop-loss constraints and trading under additional market constraints.

Convergence of Proximal Policy Gradient Method for Problems with Control Dependent Diffusion Coefficients

Schedule: July 8 16:30-17:00 Room 436

Harry Zheng

Imperial College, England

Co-Author(s): Ashley Davey

Abstract:

We prove convergence of the proximal policy gradient method for a class of constrained stochastic control problems with control in both the drift and diffusion of the state process. The problem requires either the running or terminal cost to be strongly convex, but other terms may be non-convex. The inclusion of control-dependent diffusion introduces additional complexity in regularity analysis of the associated backward stochastic differential equation. We provide sufficient conditions under which the control iterates converge linearly to the optimal control, by deriving representations and estimates of the solution to adjoint BSDEs. We introduce numerical algorithms that implement this method using deep learning and ODE-based techniques. These approaches enable high accuracy and scalability for stochastic control problems in higher dimensions. We provide numerical examples to demonstrate the accuracy and validate the theoretical convergence guarantees of the algorithms.

Ergodic McKean-Vlasov Games: Verification Theorems and Linear-Quadratic Applications

Schedule: July 8 17:30-18:00 Room 436

Chao Zhu

University of Wisconsin-Milwaukee, USA

Co-Author(s): Qingshuo Song, Gu Wang, and Zuo Quan Xu

Abstract:

This work develops a general framework for two-player ergodic nonzero-sum stochastic differential games with McKean-Vlasov dynamics. A verification theorem is established, linking solutions of a system of coupled Hamilton-Jacobi-Bellman (HJB) Master equations to Nash equilibria, which are characterized via an auxiliary bias optimal control problem formulated on the space of probability measures. The paper demonstrates that the value functions of this auxiliary control problem are uniquely determined, up to an additive constant, by the uniqueness of the invariant measure associated with the optimally controlled state process. The framework is further illustrated in a Linear-Quadratic-Gaussian (LQG) setting, where explicit solutions to the Master equations are obtained by exploiting their polynomial structure in the measure variables.

Special Session 161 : DYNAMICS AND SPECTRUM OF QUASIPERIODIC SCHRODINGER OPERATORS

Organizer(s): Qi Zhou , Wencai Liu , Zhenghe Zhang

Introduction: Quasiperiodic operators have been one of the central research areas since the late 1970s, when it was developed as a part of the general theory of ergodic operators. These theories were motivated by the studies of electron transport in various materials, such as crystals and quasicrystals, and serve as the theoretical underpinning of the Quantum Hall Effect, as well as other important physical phenomena. This session aims to facilitate academic discussions on the dynamics and spectral theory of quasiperiodic operators, covering topics such as Anderson localization, fractal related problems, KAM theory, and dynamics of cocycles. This section will bring together leading experts and promising junior researchers with interests in the study of the effects of quasiperiodicity, or other stationary environments of physical interest, and contribute to a more profound comprehension of its implications in the context of quantum theory.

Random compositions of quasi-periodic cocycles

Schedule: July 8 14:30-15:00 Room 620

Cai Ao

Soochow University, School of Mathematical Sciences, Peoples Rep of China

Co-Author(s): Pedro Duarte and Silviu Klein

Abstract:

Random compositions of quasi-periodic cocycles serve as natural extensions of random matrix products in the fields of dynamical systems, probability theory, and group theory. This talk will begin with the historical development of random matrix product theory, introduce the concept of random compositions of quasi-periodic cocycles, and present existing results in this area.

Effective parameters and exceptional integrability

Schedule: July 8 16:30-17:00 Room 620

Fernando Argentieri

IMPA, Brazil

Co-Author(s): Artur Avila

Abstract:

We study the problem of exceptional analytic integrability arising from perturbations. Our technique is based on checking the effectiveness of the available parameters. For definiteness, we will illustrate the technique with the case of one-frequency Schrodinger operators. This is joint work with Artur Avila

Aspects of quasi-periodicity in continuum models

Schedule: July 8 13:30-14:00 Room 620

Simon Becker

ETH Zurich, Switzerland

Abstract:

We review results in the analysis of continuum models of quasi-periodic magnetic Schroedinger operators, focusing on spectral and dynamical properties in regimes of physical interest. We then discuss some new directions for graphene-based systems.

Dynamical Lifshitz Tails

Schedule: July 8 14:00-14:30 Room 620

Iris Emilsdottir

University of California Irvine, USA

Abstract:

We consider one-parameter families of random circle diffeomorphisms $(g_{E,\bar{\omega}})$ for which the unperturbed map $g_{0,\bar{0}}$ has a parabolic fixed point, and the dependence on the parameter E is monotone. Under reasonable assumptions, we show that the rotation number $\rho(E)$ exhibits Lifshitz tails: doubly-exponential decay with exponent $-(2k-1)/2k$, $\lim_{E \downarrow 0} \frac{\ln(-\ln(\rho(E)-\rho(0)))}{\ln(E)} = \frac{2k-1}{2k}$. The exponent is determined by the passage time through a parabolic bottleneck. A full rotation requires on the order of $E^{-(2k-1)/2k}$ consecutive small perturbations, and the probability of such a streak decays exponentially as a function of its length. As a corollary, we provide a purely dynamical proof of the classical Lifshitz tails result for the one-dimensional Anderson model.

On Floquet and Fermi Isospectrality

Schedule: July 8 17:00-17:30 Room 620

Matthew Faust

Michigan State University, USA

Abstract:

In this talk we will discuss some recent progress on regarding the study of Fermi and Floquet isospectrality for discrete periodic Schrödinger operators. We focus our discussion on various recently proven rigidity theorems regarding Fermi and Floquet isospectrality for the discrete Laplacian on $\mathbb{Z}^d$ with nearest neighbor edges. This talk will focus on two recent works of the author, one with Brysiewicz and Liu, and another with Cobb and Kretschmer.

Generalized Aubry-Andre formula and continuity of the intersection spectrum of the Almost Mathieu operator

Schedule: July 8 8:00-8:30 Room 620

Anton Gorodetski

UC Irvine, USA

Co-Author(s): Victor Kleptsyn

Abstract:

In our joint work with Victor Kleptsyn, we consider the spectrum of the Almost Mathieu operator (AMO) and show that the moments of the restriction of the Lebesgue measure to the intersection spectrum $\text{Leb}|_{\Sigma_{\alpha,\lambda}}$ are polynomials in coupling λ with coefficients that are trigonometric polynomials in frequency α . The statement can be considered as a generalization of the Aubry-Andre's formula for the measure of the spectrum of AMO. As a corollary, we obtain that the restriction of the Lebesgue measure to the intersection spectrum that we denote by $\mu_{\alpha,\lambda}^-$ depends continuously on the parameters (frequency α and coupling λ) in weak-* topology. Moreover, we prove that the dependence is not just continuous but analytic in λ and C^∞ in α in a sense that an integral of an analytic test function $\varphi(x)$ with respect to $\mu_{\alpha,\lambda}^-$ has the same kind of dependence. As the analyticity of the test function is here required only in a neighborhood of the union spectrum $\Sigma_{\alpha,\lambda}^+$, this implies that the Lebesgue measure of the part of the spectrum $\Sigma_{\alpha,\lambda}$ that lies between two gaps depends analytically on the coupling constant λ and C^∞ on the frequency α in an open domain (away from the critical coupling $\lambda = 1$) where these gaps do not bifurcate.

Localization and spectral gaps for quasiperiodic operators with monotone potentials

Schedule: July 8 9:00-9:30 Room 620

Ilya Kachkovskiy

Michigan State University, USA

Co-Author(s): Svetlana Jitomirskaya, Leonid Parnovski, Roman Shterenberg

Abstract:

In this talk, we will discuss recent advances in perturbative Anderson localization for quasiperiodic Schrödinger operators, as well as methods based on rank one perturbation theory that allows to predict existence of spectral gaps and Cantor structure in their spectra. Based on joint papers with Svetlana Jitomirskaya, Leonid Parnovski, Roman Shterenberg.

Continuity of intersection spectrum at rationals

Schedule: July 8 15:30-16:00 Room 620

Xianzhe Li

University of California, Berkeley, USA

Abstract:

For periodic Schrödinger operators $H_{V,\alpha,x}$ with analytic potentials and frequency $\alpha \in \mathbb{Q}$. Let S_- be the intersection of the spectra over all phases x . We show that $S_-(\alpha)$ is the limit of $S_-(p/q)$ for a class of rational approximations $p/q \rightarrow \alpha$, except possibly on a set of Lebesgue measure zero. This settles a question originally raised by S. Jitomirskaya. This is a joint work with S. Jitomirskaya and L. Shao.

New universality classes associated to fractals

Schedule: July 8 8:30-9:00 Room 620

Milivoje Lukic

Emory University, USA

Co-Author(s): Benjamin Eichinger, Alexander Kheifets, Peter Yuditskii

Abstract:

The local behavior of zeros of orthogonal polynomials depends on the local properties of the measure, and different universality classes correspond to different local behaviors. From a modern perspective, this is analyzed through the scaling limits of the Christoffel-Darboux kernel. Recent works have established necessary and sufficient conditions for the most studied universality classes, including bulk universality and hard-edge universality. In all these settings, the rescaled Christoffel-Darboux kernel converges to a single limit kernel. In this talk, we introduce universality classes in which there is not a single limit kernel, but rather an entire cycle of limit kernels. We show that this type of behavior arises naturally from a fractal nature of the measure of orthogonality.

Lower Bounds for Green's Function Fractional Moments of Random Operators and Their Consequences

Schedule: July 8 15:00-15:30 Room 620

Rodrigo Matos

PUC-RIO, Brazil

Abstract:

We present lower bounds for Green's function fractional moments of discrete random Schrödinger operators. These bounds take different forms, depending on whether the operator is local or non-local, and hold in various regimes of disorder and energy. We also extract consequences for the quantum dynamics and for the eigenfunction correlators. In particular, we present regimes where the fractional Anderson model does not exhibit dynamical localization (finiteness of q -th moments of the averaged position operator for any given q) even in the presence of pure point spectrum with polynomially decaying eigenfunctions. For the Anderson model, we show optimality of exponential decay of correlators at large disorder. Based on joint works with: 1) Constanza Rojas-Molina and Peter Hislop, and 2) Sergey Sergeev.

Canonical Center Dynamics and Spectral Applications for Long-Range Operators

Schedule: July 8 17:30-18:00 Room 620

Zhenfu Wang

Nankai University, Peoples Rep of China

Co-Author(s): Xianzhe Li, Jiangong You, Qi Zhou

Abstract:

We introduce an operator-theoretic framework for long-range operators over general dynamical systems with analytic hopping and a small potential, which produces Canonical Center Dynamics. As applications, we establish the absolute continuity of the integrated density of states (IDS), quantitative Holder continuity of the IDS, and Anderson localization for large potentials.

hyperbolic geodesic flow insights and spectral theory for long-range operators

Schedule: July 8 9:30-10:00 Room 620

Disheng Xu

Great Bay University, Peoples Rep of China

Abstract:

In this talk I will present the recent joint work with Zhenfu Wang and Qi Zhou. We study the long-range operator, in particular we show any finite-range perturbation of a subcritical almost Mathieu operator, with Diophantine frequency, retains purely absolutely continuous spectrum for all phases. My talk will focus on the part that partially inspired by the study of hyperbolic geodesic flows.

Special Session 162 : Computer-Assisted Proofs in Dynamical Systems

Organizer(s): Akitoshi Takayasu , Jonathan Jaquette

Introduction: Dynamical systems serve as fundamental models for diverse phenomena in biology, physics, and chemistry. Their nonlinear character poses major analytical difficulties, which become even more severe in infinite-dimensional settings such as partial differential and delay equations. While numerical simulations are indispensable in exploring such systems, questions of validity and reliability remain central. Computer-assisted proofs (CAPs) have emerged as a rigorous methodology at the interface of numerical analysis, functional analysis, and scientific computing. This special session will highlight recent advances in CAP techniques and showcase their applications to frontier problems in finite- and infinite-dimensional dynamics.

Rigorous global search of all solution orbits for nonlinear boundary value problems

Schedule: July 7 9:30-10:00 Room 618

Taisei Asai

Yamagata University, Japan

Co-Author(s): Kazuaki Tanaka, Satoshi Tanaka, Shin'ichi Oishi

Abstract:

Nonlinear boundary value problems often exhibit rich bifurcation structures and may possess multiple solutions. From a dynamical systems perspective, such problems can be interpreted as orbit problems: solutions correspond to trajectories of an associated differential equation that satisfy prescribed boundary conditions. In this formulation, determining all solutions amounts to identifying all admissible solution orbits of the underlying dynamical system. In this talk, we present a computer-assisted framework for the rigorous global search of all such solution orbits. A central difficulty in this search is that the parameters determining trajectories, such as initial conditions in a shooting formulation, typically range over a noncompact set, making direct exploration infeasible. To overcome this difficulty, we first derive a priori bounds that confine all possible solutions to a compact set of initial conditions. This significantly reduces the set of candidates. On this set, we use the `kv` library to rigorously prove the existence or nonexistence of solutions. This approach allows us to systematically enumerate all solution orbits within a given parameter range. As an application, we present results for nonlinear elliptic problems including H^1 -type equations and discuss the resulting bifurcation structures.

Validated Numerics Guided by Symbolic Computations: A Hybrid Newton-Puiseux Algorithm

Schedule: July 7 16:30-17:00 Room 618

Florent BREHARD

CRISTAL, CNRS, Universite de Lille, France

Co-Author(s): Fabien Corinaldesi, Adrien Poteaux

Abstract:

Computing the Puiseux series of complex plane algebraic curves is a cornerstone of computational algebraic geometry, with applications ranging from robotics to theoretical physics. While the Newton-Puiseux algorithm provides a rigorous framework for desingularization, its practical efficiency is often limited by the prohibitive cost of exact arithmetic over algebraic number fields. Conversely, purely numerical approaches struggle with the inherent instability of singularities, where infinitesimal perturbations can collapse the branching structure of the curve. This work proposes a hybrid symbolic-numeric strategy that leverages validated numerics to compute rigorous interval representations of Puiseux coefficients while bypassing the cost of computing with exact algebraic numbers. Our approach utilizes the modular-numeric strategy introduced in Poteaux's thesis, where the structure of the Puiseux series is first inferred from an execution of Newton-Puiseux over a finite field, by choosing an appropriate prime number. This structural data is encoded into a polygon tree, which is then used as a blueprint guiding the numerical phase. To bridge the symbolic-numeric gap, we develop routines called filters to correctly associate the recursive calls of the numeric algorithm with the branches of these trees, thus ensuring the preservation of Newton polygons and multiplicities at every step. By doing so, we achieve a certified result where traditional interval methods alone would otherwise fail to capture the structure of the singularity. This work demonstrates how the synergy between computer algebra and validated numerics can resolve highly sensitive singular problems with both speed and mathematical rigor.

A Computer-Assisted Proof of Marchal's Conjecture in the Three-Body Problem

Schedule: July 7 14:30-15:00 Room 618

Renato C Calleja

IIMAS-UNAM, Mexico

Co-Author(s): Olivier Henot, Carlos Garcia-Azpeitia, Jean-Philippe Lessard, Jason Mireles James

Abstract:

The figure-eight choreography and the equilateral triangle solution are two remarkable periodic motions in the equal-mass three-body problem. In 2000, C. Marchal conjectured that they belong to the same continuation class, namely the highly symmetric P_{12} family of relative periodic solutions in a rotating frame. In this talk I will describe a computer-assisted proof of this conjecture. After exploiting the symmetries of the problem, the search for choreographic solutions reduces to a delay differential equation for a single body in rotating coordinates. The formulation is singular at both ends of the family, corresponding to the figure-eight and the Lagrange triangle, so the proof combines symmetry reduction with suitable desingularizations at the two endpoints. The main step is an a posteriori validation argument proving the existence of an analytic branch of periodic solutions on the whole parameter interval. The proof uses validated numerics, Fourier-Chebyshev expansions, and interval arithmetic. This is joint work with Olivier Henot, Carlos García-Azpeitia, Jean-Philippe Lessard, and Jason Mireles James.

Instability of the 2D Taylor-Green vortex

Schedule: July 7 8:30-9:00 Room 618

Gonzalo Cao-Labora

EPFL, Switzerland

Co-Author(s): Maria Colombo, Michele Dolce, Paolo Ventura

Abstract:

A Hamiltonian operator is a linear operator which can be written as JH with J skew-adjoint and H self-adjoint. We will discuss a new criterion to characterize stability and instability of Hamiltonian linear operators when H has finitely many negative directions. This criterion can be used with pen and paper mathematics to prove real instabilities, or combined with computer-assistance to prove complex instabilities. We will focus on the latter case, proving instability of certain stationary solutions of the 2-d Euler equations. More concretely, we prove the conjectured instability of the Taylor-Green vortex (or cellular flow). Our proof relies on finding zeros of a holomorphic function, using an interval arithmetic version of the Cauchy integral formula. Moreover, the computation of our holomorphic function involves a resolvent, where we capitalize on the fact that the Taylor-Green linear dynamics are local in frequency and employ a primal-dual bound to control the distance between the true resolvent and a numerical guess. We expect part of our framework to be applicable to a wider class of linear stability problems where the operator can be decomposed as the sum of a stable infinite-dimensional part plus a finite rank term causing instability.

Computer-Assisted Proofs in Random Dynamical Systems

Schedule: July 7 15:30-16:00 Room 618

Maximilian Engel

University of Amsterdam, Netherlands

Co-Author(s): Maxime Breden

Abstract:

I will summarize results from recent years on how to use computer-assisted proofs in random dynamical systems. This will concern rigorous estimates on Lyapunov exponents as indicators of synchronization or chaos as well as large deviation estimates on finite-time Lyapunov exponents as indicators of random bifurcations. The talk will also address new questions and challenges from random dynamical systems that may be approached with rigorous numerics.

On the computation of Tori and their bifurcations

Schedule: July 7 13:30-14:00 Room 618

Jordi Lluís Figueras

Dept Mathematics Uppsala University, Sweden

Abstract:

We present a computational framework for locating and continuing reducible, normally hyperbolic invariant tori with quasiperiodic internal dynamics in autonomous ordinary differential equations. The method is based on the parameterization method in a Newton-KAM formulation: the torus embedding, its normal bundle, the associated reducibility data, and selected system parameters are solved for simultaneously. Prescribing the internal frequency vector turns the search for invariant tori into a functional equation with small divisors, which we solve by Fourier-based cohomological equations adapted to dissipative flows. A pseudo-arclength continuation strategy is incorporated to detect and traverse quasiperiodic saddle-node bifurcations of invariant tori, including formulations with a distinguished normal direction. The algorithms are designed for high-dimensional systems, where direct discretizations or Poincaré-map approaches become expensive or ill-conditioned. We discuss their implementation in a C++ library and illustrate the approach on benchmark examples that exhibit convergence, continuation through folds, and robust computation of hyperbolic bundles. Although the present work is primarily numerical, the formulation is explicitly tailored to a posteriori validation, making it a natural stepping stone toward computer-assisted proofs for quasiperiodic invariant structures and their bifurcations in dissipative dynamical systems. The same framework also avoids normal-form reductions and works directly with the original vector field equations.

An ellipsoidal satellite's chaotic tumbling model

Schedule: July 7 15:00-15:30 Room 618

Anna Gierzkiewicz

Jagiellonian University in Krakow, Poland

Co-Author(s): Amadeu Delshams, Piotr Zgliczyński

Abstract:

We study the triaxial inner rotation (tumbling) of an ellipsoidal satellite in a Keplerian orbit. In our previous paper we considered a simplified uniaxial case, with the axis of rotation perpendicular to the orbital plane. The system of three ordinary differential equations is periodic with respect to one of the variables (true anomaly f), which allowed us to study the Poincaré section $f = 0 = 2\pi$. The system exhibited chaotic behavior for some parameters (the shape of the ellipsoid and the orbital eccentricity e). We are particularly interested in the values corresponding to Hyperion, one of Saturn's moons, known for its non-spherical shape and apparently chaotic inner rotation. The uniaxial model does not provide a full physical description of Hyperion's tumbling, which is clearly triaxial. The full model, based on Euler's rigid-body equations, leads to a much more complicated system of seven ordinary differential equations (omitted here for reasons of size), of which the simplified uniaxial model is an invariant subspace. For this reason, it too is chaotic, but we expect the structure of this chaos to be more complex in the 7-dimensional space: perhaps it is divided into chaotic regions connected by homo- and heteroclinic orbits. Using the Interval Newton Method implemented in C++ with the use of CAPD library for computer-assisted proofs, we found a number of periodic orbits for the analogous Poincaré map in the full space. The current work is to study the behavior of their weakly stable and unstable manifolds which seem to intersect transversely with the help of system's symmetries. This, in turn, we expect to prove rigorously with CAPD.

Modified parameterization methods in computer-assisted proofs for KAM theory

Schedule: July 7 14:00-14:30 Room 618

Alex Haro

Universitat de Barcelona & CRM, Spain

Co-Author(s): Jordi-Lluís Figueras

Abstract:

Computer-assisted proofs combine analytical arguments, rigorous numerics, and validated error bounds to turn high-precision computations into fully mathematical results. Improved analytic arguments lead directly to stronger and more efficient computer-assisted proofs, by producing less restrictive validation criteria and increasing the applicability of CAPs to concrete dynamical systems. In this talk, we discuss this paradigm in the context of KAM theory from the perspective of parameterization methods, where a posteriori invariance equations provide a natural framework to validate numerically computed invariant tori. We present new results in the form of more refined estimates, leading to more effective validation procedures. This is joint work with Jordi-Lluís Figueras (Uppsala University).

Efficient implementation of affine arithmetic for rigorous integration of delay differential equations

Schedule: July 7 17:00-17:30 Room 618

Ryoga Iwanami

Waseda University, Japan

Abstract:

In this talk, we introduce an efficient implementation of affine arithmetic. To compute tight enclosures of trajectories of dynamical systems, it is essential to suppress the wrapping effect. Although affine arithmetic can effectively reduce the wrapping effect, it tends to require significantly longer computation time compared to other methods. To address this issue, we accelerated affine arithmetic by utilizing error-free transformation, SIMD vectorization, and mixed-precision arithmetic. We will demonstrate its effectiveness by applying the accelerated implementation to several dynamical systems.

Validated matrix multiplication transform for orthogonal polynomials with applications to computer-assisted proofs for PDEs

Schedule: July 7 8:00-8:30 Room 618

Jonathan Jaquette

New Jersey Institute of Technology, USA

Co-Author(s): Matthieu Cadiot, Jonathan Jaquette, Jean-Philippe Lessard, Akitoshi Takayasu

Abstract:

In this talk, we develop computational tools related to the rigorous computational analysis of nonlinear PDEs posed on geometries such as disks and cylinders. First, we introduce a validated Matrix Multiplication Transform (MMT) algorithm, analogous to the discrete Fourier transform, which offers a reliable framework for evaluating nonlinearities in spectral methods while effectively mitigating challenges associated with rounding errors. Second, we examine the Zernike polynomials, a spectral basis well-suited for problems on the disk, and highlight their essential properties. We further demonstrate how the MMT approach can be effectively employed to compute the product of truncated Zernike series, ensuring both accuracy and efficiency. Finally, we combine the MMT framework and Zernike series to construct computer-assisted proofs that establish the existence of solutions to two distinct nonlinear elliptic PDEs on the disk.

Structures Behind Blow-Up: Algebraic-Geometric Perspectives for Computer-Assisted Proofs

Schedule: July 7 9:00-9:30 Room 618

Kaname Matsue

Institute of Mathematics for Industry / International Institute for Carbon-Neutral Energy Research, Kyushu University, Japan

Co-Author(s): Kaname Matsue

Abstract:

In this talk, we discuss methods for computing blow-up solutions of ordinary differential equations in a simple and efficient manner. Broadly speaking, there are two main approaches: one assumes the leading-order term in the asymptotic expansion of blow-up solutions, while the other reduces the problem to the construction of local stable manifolds of bounded invariant sets via compactification of the phase space. Here we examine algebraic and geometric correspondences of blow-up solutions that enable computer-assisted proofs with reduced validation estimates, while ensuring the existence of solutions with various asymptotic behaviors. In particular, the correspondence between these approaches provides different types of stability information, offering useful insights for more advanced analysis as well as numerical computation. This talk focuses on the underlying mathematical framework relevant to computer-assisted proofs and does not address the latest results in computer-assisted validation.

Symbolic dynamics in Pseudospectral projection of Delay Differential Equations

Schedule: July 7 17:30-18:00 Room 618

Robert Szczelina

Jagiellonian University, Poland

Abstract:

We study the following class of Delay Differential Equations (DDEs):
$$\begin{aligned} x'(t) &= f(x(t), x(t-\tau)) \quad t \geq 0 \\ x(t) &= \psi(t) \quad t \in [-\tau, 0], \end{aligned}$$
 with $\tau > 0$ fixed, $x \in \mathbb{R}^d$, $\psi \in \mathcal{C}^0([-\tau, 0], \mathbb{R}^d) =: \mathcal{C}$. While significant work has been done on the dynamics of such systems--most notably regarding chaos in the Mackey-Glass equation--the infinite-dimensional nature of DDEs presents some challenges for carrying out the rigorous computations and obtaining estimates good enough for computer-assisted proofs remains a challenge. This talk will present a recent attempt to reduce the number of unknown factors affecting the quality of rigorous numerics by using a pseudospectral approximation, which reduces the DDE to a relatively small system of ODEs while preserving numerically observed dynamical features. Due to the low-dimensionality of the resulting approximation and its great theoretical accuracy, the computations are less demanding and can be done using known tools, such as CAPD, to efficiently verify some dynamical phenomena that closely mirror those of the full system. We present a proof of existence of symbolic dynamics in the ODE approximating DDE and we discuss lessons learned that might be used to guide a similar proof for the full DDE system. The author acknowledges the support of Polish National Science Center (NCN) grant no. 2023/49/B/ST6/02801.

Multi-stepping scheme for rigorous integration of semilinear parabolic PDEs

Schedule: July 7 18:30-19:00 Room 618

Akitoshi Takayasu

University of Tsukuba, Japan

Co-Author(s): Jean-Philippe Lessard

Abstract:

In this talk, we present an improved integrator for the study of solutions to initial and boundary value problems for semilinear parabolic PDEs. Our method is based on a non-autonomous semigroup approach, in which the solution map of the linearized PDE along a numerically computed approximate solution is rigorously controlled. In particular, the use of a multi-stepping scheme, based on a new construction of the multi-step propagator via direct backward iteration, allows us to integrate over much longer time intervals. For each time step, we split the dynamics into a signed finite-dimensional bare propagator and a finite-tail coupling correction. The bare propagators are composed at the signed matrix level, which preserves cancellation effects and significantly reduces the wrapping effect. We also present examples for both initial value problems and boundary value problems, including long-time rigorous integration of the Ohta--Kawasaki equation.

Computer-assisted bifurcation point validation

Schedule: July 7 18:00-18:30 Room 618

Thomas Wanner

George Mason University, USA

Co-Author(s): Maxime Breden, Evelyn Sander

Abstract:

Parabolic partial differential equations are fundamental models for many applied phenomena. For example, pattern formation in diblock copolymers is described by the evolution of the fourth-order Ohta-Kawasaki equation, while competition in the interaction of populations can be modeled by second-order reaction-diffusion systems such as the Shigesada-Kawasaki-Teramoto model. Essential for a deeper understanding of the long-term dynamics of such problems are the sets of equilibria as described by the associated bifurcation diagrams. In this talk, we present computer-assisted proof techniques which can be used to validate and continue bifurcation points through the use of suitable extended systems. This includes not only fold points, but also pitchfork and transcritical bifurcations which are the result of group actions beyond forcing through involutions. Our results apply to both one- and two-dimensional domains, and they can also be used to treat certain bifurcation points with higher-dimensional kernels.

Special Session 163 : Mathematical Modeling of Multiphysics Coupled Systems—Models, Algorithms, and Scalable Computing

Organizer(s): Yifan Wang , Haibiao Zheng , Yizhong Sun

Introduction: Whether we are modeling lab-on-a-chip microfluidics, tracking micro-plastics in the bloodstream, optimizing offshore wind-turbine aerodynamics, or simulating plasma behavior in fusion reactors, we encounter the same multiphysics challenge: viscous flow, electro-osmosis, particulate or solute transport, biochemical reactions, aerodynamic or magnetic loads, structural deformation, and thermal exchange are entangled in tight feedback loops. These diverse applications share a core challenge: solving nonlinear and strongly coupled system of partial differential equations with rigorously quantified uncertainty. This special session will unite mathematicians, computational scientists, and engineers to advance the state of the art in model formulation, algorithm design, and scalable implementation for multiphysics PDEs. Topics include monolithic and partitioned time- integration, physics-aware preconditioners, reduced-order and surrogate modeling, and open-source ecosystems for multiphysics simulations that foster reproducibility. By exchanging best practices and spotlighting pressing engineering problems, participants will identify common bottlenecks, spark collaborations, and outline a roadmap for next generation multiphysics simulation at exascale.

Mixed Finite Element Methods for Boundary Control Problems Constrained by the Biharmonic Equation

Schedule: July 9 9:00-9:30 Room 314

Giorgio Bornia

Alma Mater Studiorum University of Bologna, Italy

Abstract:

We study boundary optimal control problems governed by the biharmonic equation, motivated by applications in thin plate deformation and structural optimization. The presence of boundary controls introduces analytical and numerical challenges due to the involvement of fractional Sobolev trace spaces. In particular, the control variable is defined on the boundary and naturally belongs to fractional spaces, which complicates both the functional setting and the numerical approximation. Additionally, the fourth-order structure of the biharmonic operator requires higher regularity of the state variable, posing a challenge on classical conforming discretizations. To address these difficulties, we employ a lifting strategy that decomposes the state variable into a homogeneous component and a lifting function encoding the boundary control. This reformulation transforms the original boundary control problem into a distributed one, thereby avoiding the explicit treatment of fractional spaces. The resulting system is discretized using a Hermann--Miyoshi mixed finite element method. This approach reduces the fourth-order equation to a system of lower-order equations and allows the use of standard finite element spaces. We analyze the well-posedness of the continuous optimal control problem and derive a first-order necessary condition. Numerical experiments are presented to demonstrate the effectiveness of the formulation

Unconditionally energy-stable, and fully discrete finite element schemes for the Rosensweig model

Schedule: July 9 14:30-15:00 Room 314

Xiaojing Dong

Xiangtan University, Peoples Rep of China

Co-Author(s): Xiaojing Dong, Huayi Huang, Yunqing Huang

Abstract:

Ferrohydrodynamics (FHD) describes the motion of a magnetic fluid, usually called a ferrofluid. A ferrofluid is a stable colloidal fluid consisting of nanoscale ferromagnetic particles suspended in a carrier fluid. A colloidal ferrofluid can keep magnetization and fluidity under the action of an external magnetic field. The constitutive equation we consider, proposed by Rosensweig, models fluid dynamics, spins of ferromagnetic particles, magnetic polarization, and a magnetic induction field. The corresponding model incorporates the Navier-Stokes equations, the angular momentum equation, the magnetization equation, and the magnetostatic equation. In this talk, we propose linear, unconditionally energy-stable, and fully discrete finite element schemes for the model. We obtain the existence and uniqueness of the numerical solutions by the Leray-Schauder fixed point theorem, and prove the unconditional convergence through the Aubin-Lions-Simon lemma. Numerical experiments verify the effectiveness and accuracy of the schemes, and simulate the controllability of the magnetic fluid driven by an applied magnetic field.

Neural enrichment finite element method: A hybrid method for problems with strong oscillations and interface problems

Schedule: July 9 17:30-18:00 Room 314

Shihan Guo

Otto von Guericke University Magdeburg, Germany

Co-Author(s): Thomas Richter

Abstract:

We propose a hybrid method, the Neural Enrichment Finite Element Method (NEFEM), designed for problems involving strong oscillations or discontinuities. This method is based on stable generalized FEM (SGFEM) framework, wherein neural networks (NNs) are introduced as enrichment functions for adaptivity, and the Ritz functional is applied for training process. The advancements are twofolds. First, the method constructs local subspaces with superior approximation properties, significantly reducing the required number of degrees of freedom (DoFs). Second, minimal *a priori* knowledge is required to define enrichment functions, as the NNs evolve heuristically during training. Furthermore, for smooth problems, we provide a residual-based error estimator and prove both its reliability and efficiency. For interface problems, a theoretical analysis on the optimal convergence of the stable GFEM is studied, notably without imposing additional regularity assumptions. These analysis results guide the network architecture design and training strategies. The performance and effectiveness of the proposed method are validated through several numerical experiments.

Novel unconditionally stable regularization schemes for the Navier-Stokes equations

Schedule: July 9 8:30-9:00 Room 314

Ping Lin

University of Dundee, Scotland

Abstract:

In the talk we report novel first- and second-order decoupled schemes for the Navier-Stokes equations based on the penalty method and the sequential regularization method (SRM), respectively. These schemes do not require the boundary condition on the pressure and thus preserve the original velocity boundary conditions. By using the idea of the scalar auxiliary variable (SAV), the nonlinear terms of these schemes are treated explicitly. We also carefully reformulated the Navier-Stokes equations to ensure convergence of the proposed scheme without any restriction on the time step. At each time step it is only necessary to solve elliptic equations with constant coefficients. An unconditional (without time step constraints) global optimal error estimate is shown. Furthermore, to more accurately approximate the incompressibility constraint without introducing extra stiffness into the system, a sequential regularization SAV scheme is developed, and its error estimate is provided as well. Finally, we compare our proposed schemes with the classic linearized projection scheme to demonstrate its accuracy and efficiency, and discuss the application of the idea to phase-field models. This is a joint work with Z Wang.

Fast Operator-Splitting Methods for Nonlinear Elliptic Equations

Schedule: July 9 16:30-17:00 Room 314

Hao Liu

Hong Kong Baptist University, Hong Kong

Co-Author(s): Jingyu Yang, Shingyu Leung, Jianliang Qian

Abstract:

Nonlinear elliptic problems arise in many fields, including plasma physics, astrophysics, and optimal transport. In this talk, we present our recent work on a novel operator-splitting/finite element method for solving such problems. We begin by introducing an auxiliary function in a new way for a semilinear elliptic partial differential equation, leading to the development of a convergent operator-splitting/finite element scheme for this equation. The algorithm is then extended to fully nonlinear elliptic equations of the Monge-Ampere type, including the Dirichlet Monge-Ampere equation and Pucci's equation. This is achieved by reformulating the fully nonlinear equations into forms analogous to the semilinear case, enabling the application of the proposed splitting algorithm. In our implementation, a mixed finite element method is used to approximate both the solution and its Hessian matrix. Numerical experiments show that the proposed method outperforms existing approaches in efficiency and accuracy, and can be readily applied to problems defined on domains with curved boundaries.

A Priori and a Posteriori Error Estimate for Pressure Robust Schemes for Incompressible Flow

Schedule: July 9 15:00-15:30 Room 314

Lin Mu

University of Georgia, USA

Abstract:

The incompressible fluid model is widely used in various fields in engineering and science and their numerical solutions are of prominent importance in understanding complex, natural, engineered, and societal systems. There has been considerable interest in mathematical modeling and algorithm development. One of the critical challenges is the development of the pressure robust scheme and achieve the desired mass conservation with low cost. Our effort aims at designing the low-cost divergence preserving finite element method and in turn, achieve viscosity independent velocity error estimates. Translating this result to the incompressible fluid equations, our algorithm is robust with varying viscosity permeability values and large pressure gradients. In this talk, we shall present our algorithm development, and then demonstrate the stability and convergence analysis theoretically and numerically. The profiles of benchmark tests indicate that our algorithm outperforms other non-divergence preserving numerical schemes.

Ensemble decoupled algorithms for dual-porosity-Stokes model with random physical parameters

Schedule: July 9 17:00-17:30 Room 314

Li Shan

Shantou University, Peoples Rep of China

Abstract:

The coupling of dual porosity seepage flow with free flow arises in modeling fractured porous media with large conduits. Those problems are encountered in many applications, like petroleum extraction, hydrology, geothermal systems and so on. However, accurate simulations are usually not feasible due to the fact it is physically impossible to know the exact parameter values in the model of interest. In this talk, we focus on the fast simulation for the dual-porosity-Stokes system with random physical parameters. Based on ensemble idea, we propose three decoupled algorithms and provide their stabilities and optimal error estimations. Besides, the numerical tests verify our theoretical results.

A RBF Meshless Galerkin Method for Elliptic Dirichlet Boundary Control on Curved Domains

Schedule: July 9 15:30-16:00 Room 314

Yizhong Sun

Hong Kong Baptist University, Peoples Rep of China

Co-Author(s): Leevan Ling, Shu Ma, Weifeng Qiu, Yizhong Sun

Abstract:

We develop and analyze a RBF meshless Galerkin method for elliptic Dirichlet boundary control problems on smooth curved domains. The method is posed on the exact curved domain and imposes the inhomogeneous Dirichlet boundary condition weakly by a Nitsche-type formulation. This avoids the geometric errors introduced when curved boundaries are approximated by polynomial boundary-fitted meshes. Using Bernstein inequalities for kernel-based trial spaces, we derive kernel-based inverse and trace estimates tailored to this boundary control setting. These estimates allow us to prove the stability and optimal error estimates of the proposed method. Numerical experiments on smooth domains with curved boundaries confirm the theoretical convergence rates. The approach can also provides a basis for extensions to curved interface problems, in particular to multi-domain coupled problems with curved interfaces.

Explicit Splitting Scheme for Fluid-Poroelastic Structure Interaction Problems and its Error Analysis

Schedule: July 9 9:30-10:00 Room 314

Yifan Wang

Texas Tech University, USA

Co-Author(s): Yifan Wang, Jeonghun Lee, Suncica Canic

Abstract:

We present an a priori error analysis for a fully discrete, parallelizable, explicitly coupled splitting scheme for fluid--poroelastic structure interaction problems modeled by the time-dependent Stokes--Biot system. The method decouples the fluid and poroelastic subproblems in a fully explicit manner, enabling the two systems to be solved independently at each time step while consistently enforcing the interface conditions. This structure makes the scheme computationally efficient and well suited for partitioned implementations. The analysis is carried out within a discrete energy framework. We introduce Ritz-type projections in the fluid and poroelastic subdomains and compare the fully discrete scheme with a time-discrete continuous formulation. This yields reduced error equations in which the leading interpolation terms cancel, leaving only consistency errors associated with temporal discretization and lagged interface data arising from the explicit splitting. Using these reduced equations, we derive a discrete error energy identity and establish unconditional error estimates in a combined energy--dissipation norm through a Gronwall-type argument. The resulting bounds prove first-order accuracy in time and optimal convergence in space, with rates determined by the polynomial degree of the finite element spaces. Numerical experiments based on manufactured solutions confirm the theoretical results, showing first-order temporal convergence for all variables and optimal spatial convergence rates.

A Locking-free and Loosely Coupled Robin-Robin Scheme for Fluid-Poroelasticity Interaction

Schedule: July 9 18:00-18:30 Room 314

Xiaohe Yue

Leibniz University Hannover, Germany

Co-Author(s): Wenlong He, Thomas Wick, Xiaohe Yue, Jiwei Zhang, Haibiao Zheng

Abstract:

We propose a loosely coupled scheme for the incompressible fluid-fully dynamic poroelasticity interaction (FPSI) problem, which is locking-free for extreme model parameters. By introducing two new auxiliary variables, the poroelastic system is reformulated into a four-field formulation, which can be regarded as a coupling of a dynamic Stokes-like system and a diffusion system. The decoupled scheme is constructed based on Robin-Robin type coupling conditions, evaluating the right-hand side of these conditions at the previous time step. The resulting scheme is fully parallel, meaning that the fluid subsystem and poroelasticity subsystem can be solved independently and concurrently at each time step without expensive sub-iterations. Furthermore, we prove that the scheme is unconditionally stable and provide an error estimate showing that the convergence in the H^1 norm is optimal. The error analysis demonstrates that our scheme is robust against extreme model parameters, thereby eliminating the locking inherent in the poroelastic system. Various numerical experiments are presented to validate the stability, convergence and locking-free performance of the proposed scheme.

**General numerical framework to derive structure preserving reduced order models for
thermodynamically consistent reversible-irreversible PDEs**

Schedule: July 9 14:00-14:30 Room 314

Jia Zhao

University of Alabama, USA

Abstract:

In this talk, I will present a general numerical framework to derive structure-preserving reduced-order models for thermodynamically consistent PDEs. Our numerical framework has two primary features: (a) a systematic way to extract reduced-order models for thermodynamically consistent PDE systems while maintaining their inherent thermodynamic principles and (b) a general process to derive accurate, efficient, and structure-preserving numerical algorithms to solve these reduced-order models.

Special Session 164 : Periodic and Ergodic Schrodinger Operators

Organizer(s): Matthew Faust , Ilya Kachkovskiy , Omar Hurtado

Introduction: Schrödinger operators appear frequently in many facets of modern quantum physics. These operators and the methods developed to analyze them have been crucial in understanding the transport properties of various systems, including crystals, quasicrystals, crystals with random impurities, disordered spin models, and many other models in mathematical physics. Recently, applications of algebraic geometry have found a role in the study of these operators and their generalizations, leading to a spike of interest in quantum graphs, Fourier quasicrystals, and Fermi varieties. The primary goal of this special session is to bring together a broad group of junior and senior researchers in various fields related to the spectral theory of Schrödinger operators with additional structure, including but not limited to: periodic operators, quasiperiodic operators, discrete and quantum graphs, random operators, and topological quantum systems.

Hidden Criticality and the Critical Dry Ten Martini Problem

Schedule: July 9 9:30-10:00 Room 740

Dan Borgnia

University of California, Berkeley, USA

Co-Author(s): Dan Borgnia, Robert-Jan Slager

Abstract:

The almost Mathieu operator (AMO) famously hosts a 1D metal-insulator phase transition. Away from the transition, the AMO spectrum has been shown to form a Cantor set for all irrational frequencies (Ten Martini Problem) with all labeled gaps open (Dry Ten Martini Problem). This work closes problem for the remaining $\lambda = 1$ critical point at Diophantine frequencies, showing the critical AMO Cantor set spectrum attains all labeled gaps. Our proof depends on two key ingredients: (1) Sub/Supercritical Embedding -- Hidden singularities of critical AMO in the chiral gauge and a finite similarity transform permit us to embed finite-volume restrictions of the critical AMO into the non-critical operator. (2) Bulk-Edge Correspondence -- The closing of labeled gaps at $\lambda = 1$ forces small rank-one errors via bulk-edge correspondence and permit the gluing of the finite-volume restrictions back together. Together, these imply that if a labeled gap closes, the infinite critical operator may be glued together and fully embedded in any non-critical operator (at re-scaled energy) for which the non-critical AMO resolvent is lower bounded by a diverging critical AMO resolvent. This is too strong a condition and violates the AMO gap continuity, arriving at a contradiction.

Anderson localization for analytic quasi-periodic Schrödinger operators

Schedule: July 9 9:00-9:30 Room 740

Hongyi Cao

Peking University, Peoples Rep of China

Co-Author(s): Yunfeng Shi, Zhifei Zhang

Abstract:

In this talk, we discuss some recent progress on Anderson localization for quasi-periodic Schrödinger operators on $\mathbb{Z}^d$ with analytic potentials and fixed Diophantine frequencies.

Weak separability and partial Fermi isospectrality of discrete periodic Schrödinger operators

Schedule: July 9 14:30-15:00 Room 740

Jifeng Chu

Hangzhou Normal University, Peoples Rep of China

Abstract:

We consider the discrete periodic Schrödinger operators $\Delta + V$ on $\mathbb{Z}^d$, where V is Γ -periodic with $\Gamma = q_1\mathbb{Z} \oplus q_2\mathbb{Z} \oplus \cdots \oplus q_d\mathbb{Z}$ and positive integers $q_j, j = 1, 2, \dots, d$ are pairwise coprime. By introducing the notions of generalized partial Fermi isospectrality and weak separability, we prove that two generalized partially Fermi isospectral potentials have the same weak separability. As a direct application, we prove that two potentials have the same $(d_1, d_2, \dots, d_r)$ -separability by assuming that the projections of Fermi varieties or Bloch varieties on some 3-dimensional subspace are the same, instead of the coincidence of the whole Fermi varieties or Bloch varieties. Besides, we prove that each couples of components of the generalized Fermi isospectral potentials are Floquet isospectral.

Sharp Polynomial Decay Bounds for Multidimensional Periodic Schroedinger Operators

Schedule: July 9 14:00-14:30 Room 740

Christoph Fischbacher

Baylor University, USA

Abstract:

In this talk, I will present our results on discrete periodic Schroedinger operators in arbitrary dimensions in the large coupling regime. We establish that both the Lieb-Robinson velocity and the asymptotic velocity decay at an inverse polynomial rate in the coupling, with the precise exponent determined by the period of the underlying potential. In particular, we show sharp polynomial decay rates that capture the precise dependence on the periodic structure

The Fourier Ratio and Chang's Lemma

Schedule: July 9 15:30-16:00 Room 740

Giovanni Garza

University of Delaware, USA

Co-Author(s): K. ALDALEH, W. BURSTEIN, G. GARZA, G. HART, A. IOSEVICH, J. IOSEVICH, A. KHALIL, J. KING, N. KULKARNI, T. LE, I. LI, A. MAYELI, B. MCDONALD, K. NGUYEN, AND N. SHAFFER

Abstract:

Given a function $f : \mathbb{Z}_N \rightarrow \mathbb{C}$, we denote by $\widehat{f}$ its Fourier transform which is given by

$\widehat{f}(m) = \frac{1}{\sqrt{N}} \sum_{x \in \mathbb{Z}_N} e^{-2\pi i x m / N} f(x)$. We introduce the function $\text{FR}(f) = \frac{\|\widehat{f}\|_1}{\|\widehat{f}\|_2}$, and examine how this ratio tells us the

extent to which we can approximate f by a low degree trigonometric polynomial. Finally, we prove a generalized version of Chang's lemma and show that the sparse spectrum approximation of f has some additive structure.

Moduli of Continuity of Lyapunov Exponents for Random Non-Invertible Cocycles

Schedule: July 9 16:30-17:00 Room 740

Tome Filipe Silvestre T. Graxinha

Centro de Estudos Matematicos - Universidade de Lisboa, Portugal

Co-Author(s): Pedro Duarte

Abstract:

We study the quantitative regularity of Lyapunov exponents for non-compact and non-invertible random linear cocycles, with respect to the Wasserstein distance. Our first main result shows that, under three natural hypotheses (finite exponential moments, quasi-irreducibility, and a spectral gap $L_1 > L_2$) the top Lyapunov exponent depends locally Hölder-continuously on the measure that governs the dynamics. The proof relies on a spectral method in which the strong mixing of the associated Markov operator is crucial. To that end, we extend Furstenberg-Kifer theory beyond the invertible setup. Consequences include Hölder continuity of higher exponents via exterior powers, large-deviations--type estimates, and applications to Schrödinger cocycles with unbounded potentials. Our second main result shows that the exponential moment assumption is sharp. We construct non-compact random Schrödinger cocycles with locally uniform sub-exponential moments but without any exponential moment, for which the Lyapunov exponent, as a function of the energy, fails to be α -Hölder for every $\alpha > 0$. More generally, we provide a correspondence between moment profiles and moduli of continuity, and we prove that the breakdown of a given (locally uniform) moment condition prevents the corresponding modulus of continuity from holding.

Localization for the non-stationary Anderson model in two and three dimensions

Schedule: July 10 9:30-10:00 Room 740

Omar Hurtado

Georgia Institute of Technology, USA

Abstract:

We discuss a non-stationary variant of the Anderson model, a celebrated and fundamental model in the study of disordered systems in condensed matter. We will discuss localization results for such models obtained in two and three dimensions by the speaker, and (time permitting) discuss the methods, including e.g. Bernoulli decompositions and unique continuation bounds.

Inverse Eigenvalue Problems, Floquet Isospectrality and the Hilbert--Chow Morphism

Schedule: July 9 15:00-15:30 Room 740

Andreas Kretschmer

HU Berlin, Germany

Abstract:

When can we change the diagonal of a matrix without changing its spectrum? We answer this question as follows: A square matrix A admits a nonzero diagonal matrix D such that A and $A + D$ have the same spectrum if and only if there are two principal minors of A of the same size that are not equal. This relates to the classical additive inverse eigenvalue problem in numerical analysis and has implications for existence and rigidity results in the theory of Floquet isospectrality of discrete periodic Schrödinger operators. The proof employs new techniques involving Hilbert schemes of points and the infinitesimal structure of the Hilbert--Chow morphism. This is joint work with John Cobb and Matt Faust.

Ergodicity in discrete-time quantum walks

Schedule: July 10 9:00-9:30 Room 740

Kiran Kumar

New York University Abu Dhabi, United Arab Emirates

Co-Author(s): Mostafa Sabri

Abstract:

In this talk, we present some results on ergodicity for homogeneous discrete-time quantum walks on the integer lattice. The most significant result holds in dimension one and gives a complete equivalence between the absolutely continuous spectrum of the unitary operator encoding the walk and the equidistribution of its dynamics in position space. In higher dimensions, we give a criterion for full and partial ergodicity in terms of a finer property of the spectrum which we dub 'No Repeating Graphs', and distinguish how strongly the equidistribution is taking place (weak convergence vs total variation). We also present applications of our results to the ergodicity of eigenvectors for Schrödinger operators on $\mathbb{Z}$ -periodic graphs.

Singular Spectrum under a Wide Class of Perturbations

Schedule: July 9 17:00-17:30 Room 740

Constanze D Liaw

University of Delaware, USA

Co-Author(s): Eero Saksman, Sergei Treil

Abstract:

For bounded self-adjoint operators A and K on a separable Hilbert space, consider perturbed operators of the form $A + K$. We present restrictions on the singular spectrum under trace class and more general perturbations. Some of the results are for a one-parameter family of perturbations $A + tK$, as the real parameter t varies. To the best of our knowledge, these are the first statements on the singular spectrum under infinite rank perturbations.

Eigenvalues of Maximal Abelian Covers

Schedule: July 9 13:30-14:00 Room 740

Mostafa Sabri

New York University Abu Dhabi, United Arab Emirates

Co-Author(s): Wenbo Li, Michael Magee and Joe Thomas.

Abstract:

I will give a quick overview of the problem of understanding flat bands (eigenvalues) of periodic graphs. I will then focus on maximal abelian covers, which form an important class of periodic graphs, and for which we obtained a complete characterization of the flat bands in terms of the combinatorics of the base graph. Coupling this criterion with a sophisticated analysis, we proved a conjecture of Higuchi and Nomura from 2009, stating that maximal abelian covers of regular graphs have no eigenvalues. I will also mention relations between these spectral atoms and those of universal covers, which are a lot easier to analyze as there are much fewer such covers (a single one in case of a regular graph of a fixed degree, in contrast to a whole bunch of covers in case of maximal abelian ones). Based on joint work with Wenbo Li, Michael Magee and Joe Thomas.

The Dry Ten Martini Problem for Sturmian graphs

Schedule: July 9 8:30-9:00 Room 740

Gilad Sofer

Technion - Israel Institute of Technology, Israel

Co-Author(s): Ram Band

Abstract:

Are all gaps there? - a question originally posed by Mark Kac for the Almost-Mathieu operator and later termed the Dry Ten Martini Problem by Simon - asks whether all gap labels predicted by the Gap Labelling Theorem are attained by the integrated density of states. For the Almost-Mathieu operator, this problem has been resolved in almost all regimes, and for Sturmian Hamiltonians it was recently answered affirmatively, with all allowed gaps shown to be open. In this talk, we introduce a geometric analogue of this problem for operators on discrete and metric graphs generated by Sturmian subshifts, where the aperiodicity is encoded in the underlying graph structure rather than in a potential. We study ergodic Jacobi operators on such graphs and compute their gap labels explicitly. In contrast to the classical Sturmian Hamiltonians, we show that not all allowed gaps are open. The missing gaps arise from a geometric mechanism rather than a dynamical one: the local structure of the graph produces flat bands, leading to unattained gap labels. In addition, we observe that spectral bands may touch at special energies, due to a degeneracy in the effective dynamics. Based on joint work with Ram Band.

Measure estimates coming from periodic approximations

Schedule: July 10 8:30-9:00 Room 740

Lior Tenenbaum

Bar-Ilan university, Israel

Abstract:

In studying spectra of complex operators, it is often helpful to work with simpler approximations. In this talk, I will describe a method for estimating the measure of a spectrum that is approximated, in the Hausdorff sense, by spectra of periodic operators. The idea is to consider suitable "fattenings" of these spectra and show that their measures converge to that of the limiting spectrum. I will then illustrate this method with an application to aperiodic Schrödinger operators, whose underlying structures can be approximated by periodic ones.

Exponential mixing for the randomly forced NLS equation

Schedule: July 10 8:00-8:30 Room 740

Shengquan Xiang

Peking University, Peoples Rep of China

Co-Author(s): Yuxuan Chen, Shengquan Xiang, Zhifei Zhang, Jia-Cheng Zhao

Abstract:

We explore exponential mixing of the invariant measure for randomly forced nonlinear Schrödinger equation, with damping and random noise localized in space. This study emphasizes the crucial role of dispersive nonlinear smoothing and control properties.

Special Session 165 : Advances in Analysis of Mathematical Fluid Dynamics

Organizer(s): Dongjuan Niu , Robin Ming Chen , Jitao Liu

Introduction: This special session aims to provide a platform for experts and researchers to share their latest work on partial differential equations arising in fluid dynamics, fostering new ideas and collaborations. The focus will include topics such as existence and uniqueness, long-time behavior, stability and instability, and free boundary problems for incompressible and compressible Navier–Stokes equations, as well as related physical models.

Special Session 166 : Numerical methods, viscosity solutions and free boundary problems

Organizer(s): Edgard Pimentel , Ercilia Sousa

Introduction: This Special Session aims at bringing together leading experts working on the intersection of numerical analysis, (fully) nonlinear equations, and free boundary problems. Topics covered include, but are not limited to numerical methods for viscosity solutions, numerical solutions for free boundary problems, computational methods for non-monotone operators, and regularisations as a strategy to approximate non-linear models.

A PINN Framework for Identification and Control of Nonlinear PDEs with Incomplete Data

Schedule: July 8 17:00-17:30 Room 618

Elisa Calzola

University of Ferrara, Italy

Co-Author(s): Alessandro Alla, Giulia Bertaglia

Abstract:

Physics-Informed Neural Networks (PINNs) offer a data-efficient approach to solving forward and inverse problems for nonlinear PDEs under sparse observations. In this talk, we introduce an OCP-PINN architecture for open-loop optimal control of time-dependent nonlinear evolution PDEs when initial/boundary data and physical parameters are only partially known. Using the adjoint method via Lagrange multipliers, we encode the coupled optimality system (composed of state equation, adjoint equation, and optimality condition) directly into a single neural network loss function. The framework employs two PINNs in series: the first identifies unknown parameters online from scattered data of the uncontrolled nonlinear dynamics; the second uses these parameters to simultaneously reconstruct the controlled state, the adjoint, and the optimal control. We demonstrate the approach on challenging nonlinear test cases: viscous Burgers (advection-diffusion balance), Allen--Cahn (phase-field instability), and Korteweg--de Vries (nonlinear dispersive waves). Despite severe data scarcity, the method achieves accurate parameter discovery and effective control toward target states, highlighting its robustness for nonlinear problems with incomplete information.

L^p -estimates for numerical schemes of Hamilton--Jacobi equations.

Schedule: July 8 8:30-9:00 Room 618

Fabio Camilli

Univ. di Chieti Pescara, Italy

Co-Author(s): Alessio Basti

Abstract:

We establish L^p error estimates for monotone numerical schemes approximating Hamilton--Jacobi equations on the d -dimensional torus. Using the adjoint method, we first prove a L^1 error bound of order one for finite-difference and semi-Lagrangian schemes under standard convexity assumptions on the Hamiltonian. By interpolation, we also obtain L^p estimates for every finite $p > 1$. Our analysis covers a broad class of schemes, improves several existing results, and provides a unified framework for discrete error estimates.

High order Tensor-Train-based schemes for high-dimensional Mean Field Games

Schedule: July 8 9:00-9:30 Room 618

Elisabetta Carlini

Sapienza University of Rome, Italy

Co-Author(s): Luca Saluzzi

Abstract:

We present a numerical method for solving high-dimensional Mean Field Games systems. The approach combines semi-Lagrangian time discretizations with Tensor-Train decompositions to mitigate the curse of dimensionality. A smoothed policy iteration algorithm is approximated using first- and second-order schemes in time. The resulting method reduces storage and computational costs from exponential to polynomial growth in the dimension. Numerical experiments illustrate the accuracy, robustness, and scalability of the proposed approach.

Convergent Numerical approximation for fractional Mean Field Games

Schedule: July 8 14:00-14:30 Room 618

Indranil Chowdhury

Indian Institute of Technology Kanpur, India

Abstract:

We construct numerical approximations for fractional Mean Field Games, a coupled forward-backward system of nonlinear integro-differential equations involving Hamilton--Jacobi--Bellman and Fokker--Planck equations, where the diffusion is given by the fractional Laplacian. The method is based on finite differences and powers of the discrete Laplacian. The approximation is monotone, stable, and consistent. We discuss the convergence results of the numerical approximation to the given system.

A convergent discretization of the porous medium equation with fractional pressure

Schedule: July 8 16:30-17:00 Room 618

Felix del Teso

Universidad Aut\`onoma de Madrid, Spain

Abstract:

We carefully construct and prove convergence of a numerical discretization of the porous medium equation with fractional pressure,

$$\frac{\partial u}{\partial t} - \nabla \cdot (u^{m-1} \nabla (-\Delta)^{-\sigma} u) = 0, \quad (1)$$

for $\sigma \in (0, 1)$ and $m \geq 2$. The model, introduced by Caffarelli and V\`azquez in 2011, is currently one of two main nonlocal extensions of the local porous medium equation. It has finite speed of propagation, but as opposed to the other extension, it does not satisfy the comparison principle. We exploit the fact that the cumulative density $v(x, t) = \int_{-\infty}^x u(y, t) dy$ satisfies

$$\frac{\partial v}{\partial t} + |\partial_x v|^{m-1} (-\Delta)^s v = 0, \quad s = 1 - \sigma,$$

which is a nonlocal quasilinear parabolic equation in non-divergence form that can be analyzed through viscosity solution methods. The numerical method consists in discretizing this equation with a difference quadrature scheme with upwinding ideas and then computing the solution u of (1) via numerical differentiation. Our results cover both absolutely continuous and Dirac or point mass initial data, and in the latter case, machinery for discontinuous viscosity solutions is needed in the analysis.

Evolving Clusters: A Dynamical Perspective on Time-Dependent Mixture Models

Schedule: July 8 9:30-10:00 Room 618

Adriano Festa

Politecnico di Torino, Italy

Co-Author(s): Adriano Festa, Fabio Camilli, Alessio Basti

Abstract:

We propose a control-theoretic framework for evolutionary clustering based on Mean Field Games (MFG). Unlike traditional static or heuristic approaches, we recast the problem as a population dynamics game governed by a coupled Hamilton-Jacobi-Bellman and Fokker-Planck system. Driven by variational cost functional rather than predefined statistical shapes, this continuous-time formulation naturally accommodates non-parametric cluster evolution. To analytically validate our general framework, we analyze the specific setting of time-dependent Gaussian mixtures. We prove that the MFG dynamics explicitly recover the trajectories of the classic Expectation-Maximization (EM) algorithm, providing a rigorous generalization that guarantees mass conservation. Furthermore, we introduce time-averaged log-likelihood functionals to smooth short-term fluctuations. Numerical experiments confirm the validity of our approach in parametric contexts and pave the way for fully non-parametric clustering applications where classical EM methods are not applicable.

Ranking Mean-Field Planning Games

Schedule: July 8 8:00-8:30 Room 618

Diogo Gomes

KAUST, Saudi Arabia

Co-Author(s): Ali Almadah, Melih Ucer

Abstract:

This paper investigates a one-dimensional Mean-Field Planning (MFP) system characterized by non-local, rank-based interactions, where individual costs depend on an agent's relative standing within the population distribution. Using a potential formulation, we reduce the coupled system to a scalar partial differential equation and establish a rigorous equivalence between classical solutions of the ranking MFP and the associated potential problem, including explicit reconstruction formulas. By identifying a monotonicity structure within the associated operator, we prove the uniqueness of classical solutions under strict convexity assumptions. Furthermore, we address the existence of solutions in low-regularity regimes by formulating a relaxed variational inequality. Using a q-Laplacian regularization and Minty's method, we establish the existence of weak solutions in the space of functions of bounded variation (BV). These results provide a mathematical framework for deterministic first-order planning problems with cumulative distribution couplings, such as those arising in competitive models of emission regulation.

Discretization of fractional fully nonlinear equations by powers of discrete Laplacians

Schedule: July 8 14:30-15:00 Room 618

Robin Lien

Norwegian University of Science and Technology (NTNU), Norway

Abstract:

Fractional fully nonlinear PDEs such as Hamilton-Jacobi-Bellman and Isaacs equations arise naturally in optimal control and differential game theory, with many applications in engineering, science, economics, etc. We study discretizations of such equations by powers of discrete Laplacians. Our problems are parabolic and of order $\sigma \in (0, 2)$ since they involve fractional Laplace operators $(-\Delta)^{\sigma/2}$, and solutions are non-smooth in general and should be interpreted as viscosity solutions. Our approximations are realized as finite-difference quadrature approximations and are 2nd order accurate for all values of σ . The accuracy of previous approximations of fractional fully nonlinear equations depend on σ and are worse when σ is close to 2. We show that the schemes are monotone, consistent, L^∞ -stable, and convergent using a priori estimates, viscosity solutions theory, and the method of half-relaxed limits. We also prove a second order error bound for smooth solutions and present many numerical examples.

From the Monge-Ampère equation to Stochastic Optimal Control and Reinforcement Learning

Schedule: July 8 15:00-15:30 Room 618

Ivan Majic

UCL, England

Co-Author(s): Dr Max Jensen

Abstract:

The Monge-Ampère equation is a nonlinear second-order partial differential equation involving the determinant of the Hessian of an unknown function, with applications in areas such as Optimal Transport. Under appropriate conditions, the Monge-Ampère equation has an equivalent Hamilton-Jacobi-Bellman (HJB) formulation in the classical and viscosity solution sense. This talk studies a model Monge-Ampère equation through its associated HJB formulation and the corresponding Stochastic Optimal Control problem. We establish the existence of strong controls for the control problem, and use a verification theorem to connect the value function to the HJB equation and hence to the original Monge-Ampère equation. Finally, we will showcase examples of using Reinforcement Learning to solve the problem numerically.

Rates of convergence of finite element approximations of second-order mean field games with nondifferentiable Hamiltonians

Schedule: July 8 13:30-14:00 Room 618

Iain Smears

University College London, England

Co-Author(s): Yohance A. P. Osborne

Abstract:

We consider the analysis of numerical methods for second-order mean field games. In the setting of nondifferentiable Hamiltonians, the system comprises the HJB equation for the value function and the KFP partial differential inclusion for the density of the players. In the nondifferentiable setting, it is known from examples that one cannot expect any quantitative control on the error made in approximating the unknown drift term that appears in the differential inclusion. Despite this difficulty, we prove a rate of convergence for finite element approximations for such MFG systems, on general bounded polytopal Lipschitz domains with strongly monotone running costs. In particular, we obtain a rate of convergence in the H^1 -norm for the value function approximations and in the L^2 -norm for the approximations of the density.

A numerical approach to degenerate fully nonlinear elliptic problems from the pure equation to free boundaries

Schedule: July 8 17:30-18:00 Room 618

Ercilia Sousa

University of Coimbra, Portugal

Co-Author(s): Edgard Pimentel

Abstract:

We study a class of degenerate fully nonlinear elliptic equations, consisting of a pure equation and an associated transmission-type free boundary problem. First, we propose a regularization of the pure equation and develop a numerical method for the resulting regularized problem. This regularization also plays a role in ensuring the monotonicity of the numerical scheme. We prove that the method is monotone, consistent, and stable. Consequently, the Barles-Souganidis framework guarantees the convergence of the numerical approximation. Once the numerical treatment of the pure equation is established, we show how a similar approach can be extended to the free boundary transmission problem. Finally, we present numerical experiments that support the theoretical results. This work has been done in collaboration with Edgard Pimentel.

Special Session 167 : Functional spaces and multiphase problems

Organizer(s): Calogero Vetro , Marek Galewski

Introduction: The session will collect recent advancements in the analysis of spaces of functions and problems with multiple phases, also paying attention to their applications in Science and Engineering. Topics of interest include, but are not limited to, analysis of energy functionals, characterization of (non-)local and (non-)linear operators, generalized functional spaces, solutions to differential equations and inclusions, approximation methods for nonlinear partial differential equations.

A new class of anisotropic double phase problems: exponents depending on solutions and their gradients

Schedule: July 8 16:30-17:00 Room 827

Anouar Bahrouni

University of Monastir, Tunisia

Co-Author(s): Ala Eddine Bahrouni and Hlel Missaoui

Abstract:

In this talk, we deal with two novel classes of quasilinear elliptic equations, each driven by the double phase operator with variable exponents. The first class features a new double phase equation where exponents depend on the gradient of the solution. We delve into giving various properties of the corresponding Musielak-Orlicz Sobolev spaces, including the Δ_2 property, uniform convexity, density and compact embedding. Additionally, we explore the characteristics of the new double phase operator, such as continuity, strict monotonicity, and the (S_+) -property. Employing both variational and nonvariational methods, we deal with the existence of solutions for this inaugural class of double phase equations. In the second category, the treatment of exponents is dependent on the solution itself. This class differs from the first one due to the unavailability of suitable Musielak-Orlicz Sobolev spaces. For this reason, we employ a perturbation argument that leads to the classical double phase class. These two new classes highlight how different physical processes like the movement of special fluids through porous materials, phase changes, and fluid dynamics interact with each other.

Nonlinear scalar field equations with a critical Hardy potential

Schedule: July 9 14:00-14:30 Room 827

Bartosz Bieganowski

University of Warsaw, Poland

Abstract:

We study the existence of solutions for the nonlinear scalar field equation

$$-\Delta u - \frac{(N-2)^2}{4|x|^2}u = g(u), \quad \text{in } \mathbb{R}^N \setminus \{0\},$$

where the potential $-\frac{(N-2)^2}{4|x|^2}$ is the critical Hardy potential and $N \geq 3$. The nonlinearity g is continuous and satisfies general subcritical growth assumptions of the Berestycki-Lions type. The problem is approached using variational methods within a non-standard functional setting. The natural energy functional associated with the equation is defined on the space $X^1(\mathbb{R}^N)$, which is the completion of $H^1(\mathbb{R}^N)$ with respect to the norm induced by the quadratic part of the functional. We establish the existence of a nontrivial solution $u_0 \in X^1(\mathbb{R}^N)$ that satisfies the Poho\v{z}aev constraint $\mathcal{M}$ and minimizes the energy functional on $\mathcal{M}$. Furthermore, assuming g is odd, we prove the existence of at least one non-radial solution. This is a joint work with D. Strzelecki.

Lavrentiev's phenomenon and density of regular functions

Schedule: July 9 14:30-15:00 Room 827

Iwona Chlebicka

University of Warsaw, Poland

Abstract:

Modelling materials that differ from place to place require the use of unconventional, inhomogeneous space setting. One of the key structural challenge might be the lack of density of regular functions that entails irregularity or even non-existence of solutions. I will discuss what for do we need the density, how to ensure it and examples when it is not possible

Sampling-type series and approximation of differential operators

Schedule: July 9 16:30-17:00 Room 827

Rosario Corso

University of Palermo, Italy

Abstract:

Sampling series are employed in signal processing and in approximation theory to reconstruct or approximate functions from their values on discrete sets of points. One of the first results in this context is the Whittaker-Kotel'nikov-Shannon theorem for bandlimited functions. Variations of classical sampling series replace pointwise evaluations with integral averages providing flexibility, for instance, in contrast to noise. A common characteristic is the definition in terms of a so-called kernel, which may belong to various spaces of functions. In this talk we will make an overview of sampling-type series and discuss the problem of approximating differential operators.

Global small data solutions for some nonlocal semilinear evolution equations

Schedule: July 9 8:30-9:00 Room 827

Marcello DAbbicco

University of Bari, Italy

Abstract:

In this talk, we discuss some global small data existence results for semilinear evolution equations with nonlocal terms in time and/or in space, and their nonexistence counterpart.

A bifurcation phenomenon for the critical p -Laplace equation in the ball

Schedule: July 8 17:00-17:30 Room 827

Francesca Dalbono

University of Palermo, Italy

Co-Author(s): Matteo Franca, Andrea Sfecci

Abstract:

We study positive radial solutions for a Dirichlet problem associated with a class of quasilinear p -Laplace differential equations involving a critical weighted nonlinearity. We show that the existence and multiplicity of solutions exhibit a bifurcation phenomenon depending on the flatness order of the weight at zero. The existence of a second solution is new, even in the classical Laplace case. The analysis is based on a dynamical systems approach via the Fowler transformation, and the main technical contribution consists in the construction of an unstable manifold in a non-smooth setting.

Nonlinear Partial Differential Equations and Their Applications

Schedule: July 9 9:00-9:30 Room 827

Ki-Ahm Lee

Seoul National University, Korea

Abstract:

This talk presents an overview of fully nonlinear partial differential equations and their applications in differential geometry, physics, engineering, and mathematical finance. We emphasize the structural relationships among different classes of nonlinear equations and the emergence of degenerate and singular phenomena, including free boundary problems. Recent developments will be discussed.

Finite-time blow-up in a Keller-Segel model with indirect signal production

Schedule: July 9 15:00-15:30 Room 827

Xuan Mao

Hohai University, Peoples Rep of China

Co-Author(s): Meng Liu and Yuxiang Li

Abstract:

This talk focuses on a Keller-Segel chemotaxis system involving indirect signal production, which models the impact of phenotypic heterogeneity on population aggregation. The system exhibits a four-dimensional critical mass phenomenon, resulting in unbounded solutions, as first explored in the seminal works of Fujie and Senba (2017, 2019). Building upon this foundation, our recent research establishes the existence of solutions that explode in finite time, thereby providing a more complete picture of singularity formation and offering new insights into the dynamic behavior of population aggregation in the presence of indirect signal production.

Vitali theorems for varying measures

Schedule: July 9 9:30-10:00 Room 827

Valeria Marraffa

Dipartimento di Matematica e Informatica, Italy

Co-Author(s): A.R. Sambucini

Abstract:

Some limit theorems of the type

$$\int_{\Omega} f_n dm_n \rightarrow \int_{\Omega} f dm$$

are presented for scalar, (vector), (multi)-valued sequences of m_n -integrable functions f_n . Conditions for the convergence of sequences of measures $(m_n)_n$ and of their integrals $(\int f_n dm_n)_n$ in a measurable space Ω are of interest in many areas of pure and applied mathematics such as statistics, transportation problems, interactive partial systems, neural networks and signal processing. Sufficient conditions in order to obtain some kind of Vitali's convergence theorems for a sequence of (multi)functions $(f_n)_n$ integrable with respect to a sequence of measures $(m_n)_n$ are considered. We consider the asymptotic properties of $(\int_{\Omega} f_n dm_n)_n$ with respect to varying measures, which are vaguely convergent in an arbitrary measurable spaces. \bibitem{1} L. Di Piazza, V. Marraffa, K. Musia{\l}, A. Sambucini, Convergence for varying measures, J. Math. Anal. Appl., Vol. 518, N.2, Paper N. 126782, (2023). \bibitem{3} L. Di Piazza, V. Marraffa, K. Musia{\l}, A. Sambucini, Convergence for varying measures in the topological case, Annali di Matematica Pura e Applicata, (4) 203 (2024) 71-86. \bibitem{2} V. Marraffa, B. Satco, Convergence Theorems for Varying Measures Under Convexity Conditions and Applications, Mediterr. J. Math., (2022), 19:274. \bibitem{4} V. Marraffa, A.R. Sambucini, Vitali theorems for varying measure, Symmetry 2024, 16(8), 972.

Regularity theory for a class of normalized p -Laplace type equations

Schedule: July 9 17:00-17:30 Room 827

Makson Santos

University of Lisbon, Portugal

Co-Author(s): Claudemir Alcantara, Jos\`{e} Miguel Urbano

Abstract:

We study the regularity properties of viscosity solutions to a class of degenerate normalized p -Laplace type equations. In particular, we prove that the gradient of viscosity solutions is Hölder continuous, and we give the optimal exponent. Moreover, we also show that viscosity solutions to equations with very general degeneracy laws are differentiable.

Curvature obstructions to concavity preservation for the porous medium flows

Schedule: July 8 17:30-18:00 Room 827

Asuka Takatsu

The University of Tokyo, Japan

Co-Author(s): Kazuhiro Ishige and Yoshiumi Tateoka

Abstract:

We discuss how concavity properties are preserved under the porous medium flows on a Riemannian manifold, clarifying the effects of diffusion nonlinearity and curvature. In particular, curvature yields an obstruction: if the sectional curvature is negative at a given point, no concavity property is preserved. However, if the curvature is non-zero, concavity properties can only be preserved if they are stronger than those associated with the diffusion nonlinearity.

Anisotropic (p,q) -Laplacian equations with competing nonlinearities

Schedule: July 9 17:30-18:00 Room 827

Calogero Vetro

University of Palermo, Italy

Abstract:

We consider the existence of solutions to general mathematical models for physical phenomena when different spatial directions play different roles. The mathematical formulation leads to an anisotropic elliptic system of p & q type posed in a bounded domain with smooth boundary and Dirichlet boundary condition.

Special Session 168 : Stochastic Analysis and Large Scale Interacting Systems

Organizer(s): Danielle Hilhorst , Perla El Kettani , Bin Xie

Introduction: The interaction between the theory of stochastic analysis and large scale interacting systems is an important and fruitful research field, not only because of its intrinsic mathematical challenges, but also by the wide range of its applications in physics, biology, mathematical finance, engineering and so on. In this session, we aim to bring together experts in the research area of stochastic analysis on interacting particle systems arising in physics and biology, as well as in phase transitions, and related research topics including stochastic partial differential equations, rough paths, random surfaces, quantum field theory, and stochastic homogenization. It will involve methods for their stochastic analysis and will also deal with numerical algorithms for explicit computations.

Numerical Approximation of the stochastic Cahn-Hilliard equation with singular potential

Schedule: July 9 9:00-9:30 Room 313

Lubomir Banas

Bielefeld University, Germany

Co-Author(s): Stefan Metzger

Abstract:

We discuss the numerical approximation of the stochastic Cahn-Hilliard equation with a singular double-obstacle potential and multiplicative conservative noise. We propose a regularized fully discrete finite element approximation scheme for the problem and show that it satisfies stability estimates which are uniform with respect to the discretisation parameters. We show convergence of the approximation for vanishing discretisation parameters towards a regularised version of the singular stochastic Cahn-Hilliard equation by monotonicity arguments. Owing to a uniform H^1 -estimate for the regularised problem we then establish convergence of the regularised solution to the probabilistically strong solution of the stochastic Cahn-Hilliard equation with double-obstacle potential. We also present numerical simulations where we compare the regularised numerical approximation to its unregularised counterpart and illustrate the effect of the conservative noise.

Existence and Uniqueness of a 3D Nonlinear Stochastic Thermoelastic Model with Nonlinear Damping

Schedule: July 9 8:00-8:30 Room 313

Hakima Bessaih

Florida International University, USA

Co-Author(s): Mogtaba Mohammed

Abstract:

We study a three-dimensional stochastic thermoelastic system with nonlinear damping and forcing. The model couples a nonlinear elasticity equation with a heat equation driven by additive noise. Using compactness, variational, and monotonicity methods, we prove the existence of weak martingale solutions. Under additional structural assumptions on the damping and noise, we establish pathwise uniqueness. These results contribute to the analysis of stochastic thermoelastic systems with nonlinear dissipation.

Homogenisation of a Passive Scalar Transported by Locally Supported White Noise

Schedule: July 9 15:30-16:00 Room 313

Federico Butori

Scuola Normale Superiore, Pisa, Italy

Co-Author(s): Mayorcas, Avi and Morlacchi, Silvia

Abstract:

Transport-type stochastic perturbations are a common way of representing turbulent effects in fluid dynamics models. A recent research thread on the topic is the so-called Itô-Stratonovich diffusion limit. By selecting Stratonovich transport noise with carefully arranged coefficients, one can show that the solution of certain SPDEs are close, in an appropriate topology, to a deterministic equation with an effective second order elliptic operator, linked to the Ito-Stratonovich corrector. In this talk, we deal with viscous a passive scalar model. Starting from [Flandoli et al., 2022, Philos. Trans. Roy. Soc. A, 380(2219)], we consider a transport noise made by a sum of independent and compactly supported vector fields. Due to the anisotropic nature of the noise, the identification of the limit equation is not straightforward as in other examples, as the Ito-Stratonovich corrector is a generic second order elliptic operator with non-constant coefficients. Using tools from Homogenisation theory, we obtain a representation for the limiting effective diffusivity matrix. Exploiting this representation, we study both analytically and numerically asymptotics, in the zero-viscosity regime, of the effective diffusivity across a number of vector field regimes parametrised by the radius of their support.

Invariant Measures for Stochastic Fluid Flows in Bounded Domains with Permeable Boundaries

Schedule: July 8 9:00-9:30 Room 313

Fernanda Cipriano

NOVA University Lisbon, Portugal

Abstract:

This talk is devoted to the study of the well-posedness and the existence of invariant measures for a class of incompressible viscous fluids filling a 2D bounded domain with permeable boundaries, under the action of random forces.

Sharp upper bounds on hitting probabilities for the solution to the stochastic heat equation on the line

Schedule: July 10 8:00-8:30 Room 313

Robert Dalang

Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland

Co-Author(s): Fei Pu (Beijing) & David Nualart (Kansas)

Abstract:

For Gaussian random fields with values in R^d , sharp upper and lower bounds on the probability of hitting a fixed set have been available for many years. These apply in particular to the solutions of systems of linear SPDEs. For non-Gaussian random fields, the available bounds are less sharp. For systems of stochastic heat equations, a sharp lower bound was obtained in [R.C. Dalang and F. Pu, Optimal lower bounds on hitting probabilities for stochastic heat equations in spatial dimension $k \geq 1$. Electron. J. Probab. 25 (2020), Paper No. 40, 31 pp]. Here, we obtain the corresponding sharp upper bound.

Stochastic diffuse interface models driven by conservative noise

Schedule: July 8 15:30-16:00 Room 313

Andrea Di Primio

Scuola Normale Superiore, Italy

Abstract:

Diffuse interface models have attracted significant interest starting with the pioneering work of Cahn and Hilliard in 1958. In this talk, I will introduce and discuss examples of systems of Allen--Cahn and Cahn--Hilliard type perturbed by conservative noise, i.e., keeping the key mass conservation property, enjoyed by the deterministic counterparts of the systems, pathwise. The systems are endowed with a singular potential, as prescribed by the thermodynamical derivation of the model. In particular, results on existence and uniqueness of martingale and/or probabilistically-strong solutions are shown. The talk is based on joint works with Maurizio Grasselli (Politecnico di Milano), Andrea Papini (Chalmers University of Technology), Luca Scarpa (Politecnico di Milano) and Margherita Zanella (Politecnico di Milano). The mentioned activities are carried out within the project: NoisyFluid "Noise in Fluids", Grant Agreement 101053472, CUP E53C22001720006.

The vanishing latent heat limit of a stochastic Stefan problem : An error estimate

Schedule: July 10 8:30-9:00 Room 313

Perla El Kettani

University of Toulon, France

Co-Author(s): Ioana Ciotir, Dan Goreac, Danielle Hilhorst.

Abstract:

We extend an article by Hilhorst, Mimura and Schatzle about the limit as the latent heat coefficient tends to zero of a two-phase Stefan problem arising in biology. We introduce a one-dimensional additive white noise in time, and search for the limit of the solution of the corresponding stochastic Stefan problem as the latent heat coefficient vanishes. We first prove the existence and uniqueness of the weak solution of this problem, and then study the limit of the solution as the latent heat coefficient tends to zero. Our method of proof is based upon an error estimate between the solution of the Stefan problem with positive latent heat and the one of the Stefan problem with zero latent heat, which seems to be novel even in the deterministic case when no noise is added.

Optimal Regularity and Stability for Numerical Schemes of SPDEs via functional calculus

Schedule: July 9 8:30-9:00 Room 313

Foivos F Evangelopoulos-Ntemiris

TU DELFT, Netherlands

Abstract:

The H^∞ -calculus provides a powerful framework for establishing well-posedness and optimal regularity results for stochastic partial differential equations (SPDEs). In particular, it is the cornerstone for proving stochastic maximal regularity, a crucial tool for handling non-linear SPDEs via linearization techniques. While this continuous theory is well-established, its applications to numerical analysis---specifically for deriving sharp stability and convergence rates for numerical schemes---have only recently begun to emerge. In this talk, I will present a framework for establishing a priori regularity estimates for semi-discrete numerical schemes of linear SPDEs, which subsequently enable the convergence analysis of non-linear problems. The core of this approach relies on proving the uniform boundedness of the H^∞ -calculus for the finite element discretizations $\{A_h: h > 0\}$ of a second-order elliptic operator A .

Kolmogorov equations for stochastic Volterra processes with singular kernels

Schedule: July 8 14:00-14:30 Room 313

Ioannis Gasteratos

TU Berlin, Germany

Co-Author(s): Alexandre Pannier

Abstract:

We associate backward and forward Kolmogorov equations to a class of fully nonlinear Stochastic Volterra Equations (SVEs) with convolution kernels K that are singular at the origin. Working on a carefully chosen Hilbert space $\mathcal{H}_1$, we rigorously establish a link between solutions of SVEs and Markovian mild solutions of a Stochastic Partial Differential Equation (SPDE) of transport-type. Then, we obtain two novel Itô formulae for functionals of mild solutions and, as a byproduct, show that their laws solve corresponding Fokker-Planck equations. Finally, we introduce a natural notion of singular directional derivatives along K and prove that (conditional) expectations of SVE solutions can be expressed in terms of the unique solution to a backward Kolmogorov equation on $\mathcal{H}_1$. Our analysis relies on stochastic calculus in Hilbert spaces, the reproducing kernel property of the state space $\mathcal{H}_1$, as well as crucial invariance and smoothing properties that are specific to the SPDEs of interest. In the special case of singular power-law kernels, our conditions guarantee well-posedness of the backward equation either for all values of the Hurst parameter H , when the noise is additive, or for all $H > 1/4$ when the noise is multiplicative.

Large Deviations for the Porous Medium Equation via Multiscale Integrability

Schedule: July 9 13:30-14:00 Room 313

Benjamin Gess

TU Berlin, MPI MiS Leipzig, Germany

Abstract:

This talk investigates a large deviation principle for a class of zero-range particle systems whose macroscopic behavior is governed by the porous medium equation. The result applies in the full small-particle regime and extends earlier work that required stronger restrictions on the scaling. The main difficulty is that the model combines degenerate diffusion with superlinear growth, so the standard methods used in hydrodynamic large deviations, like two-block estimates, do not apply. The key new idea is a multiscale approach that recovers enough effective regularity at intermediate scales to obtain the necessary superexponential and uniform integrability estimates. In this talk, I will describe the particle model, explain where the usual replacement arguments break down, and show how coarse-graining and multiscale integrability make it possible to obtain the large deviation principle in complete generality.

Solitary Waves in a Stochastic Parametrically Forced Nonlinear Schrödinger Equation

Schedule: July 8 9:30-10:00 Room 313

Manuel Gnann

TU Delft, Netherlands

Co-Author(s): Rik Westdorp and Joris van Winden

Abstract:

We study a parametrically forced nonlinear Schrödinger (PFNLS) equation, driven by multiplicative translation-invariant noise. We show that a solitary wave in the stochastic equation is orbitally stable on a timescale which is exponential in the inverse square of the noise strength. We give explicit expressions for the phase shift and fluctuations around the shifted wave which are accurate to second order in the noise strength. This is done by developing a new perspective on the phase-lag method introduced by Krüger and Stannat.

Stochastic Maximum Principle for Delay Equations: the Non-Convex Case

Schedule: July 8 13:30-14:00 Room 313

Giuseppina Guatteri

Politecnico di Milano, Italy

Co-Author(s): Federica Masiero

Abstract:

This talk is based on joint work with Federica Masiero. We discuss a stochastic maximum principle for controlled stochastic differential equations with delay in the state, control-dependent noise, and non-convex control sets. The cost functional may depend on both the present state and its weighted past through general finite measures. In the regular case, where the delay measures admit square-integrable densities, the problem can be reformulated as an infinite-dimensional stochastic evolution equation in a Hilbert space, and necessary optimality conditions are derived through spike variation and first- and second-order adjoint equations. For general finite measures, including pointwise delays, the analysis combines anticipated backward stochastic differential equations with an approximation procedure for the second-order term. This yields a stochastic maximum principle beyond the convex setting and clarifies the role of infinite-dimensional methods in delay control problems.

Nonlinear stochastic PDEs in biochemical systems

Schedule: July 8 8:30-9:00 Room 313

Erika Hausenblas

Technical University of Leoben, Austria

Co-Author(s): Deboprija Mukherjee

Abstract:

Nonlinear partial differential equations (PDEs) arise naturally in many biological and chemical systems, particularly in the context of cross-diffusion systems such as chemotaxis. Additionally, random fluctuations are prevalent in the real world, and this randomness can lead to various new phenomena that significantly impact the behavior of the solutions. The introduction of a stochastic term (or noise) in the model often results in qualitatively new behaviors, enhancing our understanding of real processes and often making them more realistic. The interplay between noise and nonlinearity can give rise to effects such as noise-induced transitions, stochastic resonance, metastability, or even noise-induced chaos. In the case of simple Keller-Segel models, a dichotomy exists based on the initial mass; depending on this mass, a blow-up phenomenon may occur. However, it is possible to suppress this blow-up by introducing an additional term. When incorporating some multiplicative noise, the mass may change over time. In this scenario, it is also possible to demonstrate the existence of a global solution if a proliferation term or a porous media term is included. In the talk, we will introduce some Keller-Segel systems for which a global solution exists even in the two-dimensional case.

Fernique-type bounds for BPHZ models and their applications

Schedule: July 8 16:30-17:00 Room 313

Masato Hoshino

Institute of Science Tokyo, Japan

Co-Author(s): Ismael Bailleul and Ryoji Takano

Abstract:

For general locally subcritical parabolic singular SPDEs without variance blow-up, we prove that the BPHZ model satisfies a Fernique-type theorem, namely exponential square integrability, whenever the driving noise is stationary and satisfies a suitable Poincaré inequality. As applications, we obtain two consequences. First, if the SPDE admits appropriate a priori estimates, then its solution satisfies a corresponding concentration inequality. Second, we show that the BPHZ model satisfies a Schilder-type large deviation principle, and that the solution to the SPDE satisfies a Freidlin-Wentzell-type large deviation principle, extending the result of Hairer and Weber (2015).

Fractional Diffusion Bridges

Schedule: July 8 15:00-15:30 Room 313

Yuzuru Inahama

Kyushu University, Japan

Abstract:

Consider stochastic differential equations driven by fractional Brownian motion with Hurst parameter $H \in (1/4, 1)$. Their solutions are sometimes called fractional diffusion processes. The main purpose of this talk is conditioning these processes to reach a given terminal point. We call the conditioned processes fractional diffusion bridges. Our main tool for mathematically rigorous conditioning is quasi-sure analysis, which is a potential theoretic part of Malliavin calculus. We also prove a small-noise large deviation principle of Freidlin-Wentzell type for scaled fractional diffusion bridges under a mild ellipticity assumption on the coefficient vector fields.

Stroock-Varadhan martingale problem of Young stochastic differential equations

Schedule: July 9 9:30-10:00 Room 313

Chengcheng Ling

University of Augsburg, Germany

Abstract:

Under mild regularity assumptions, we prove that the martingale problem associated with the hybrid Young-Lyons-Itô differential equation admits a unique solution, thereby establishing probabilistic weak well-posedness. Our proof relies on the analysis of the associated Kolmogorov equations, which are Young-type parabolic PDEs with singular coefficients. The resulting theory for such singular Young-type parabolic PDEs is also of independent interest.

On the short memory limit in a stochastic Coleman-Gurtin model of heat conduction

Schedule: July 8 17:30-18:00 Room 313

Vincent R Martinez

CUNY Hunter College & Graduate Center, USA

Co-Author(s): Nathan Glatt-Holtz, Vincent R. Martinez, Hung D. Nguyen

Abstract:

This talk presents recent results on a class of semi-linear differential Volterra equations with polynomial-type potentials that incorporates the effects of memory while being subjected to random perturbations via an additive Gaussian noise. We show that for a broad class of non-linear potentials and sufficiently regular noise the system always admits invariant probability measures, defined on the extended phase space, that possess higher regularity properties dictated by the structure of the nonlinearities in the equation. Furthermore, we investigate the singular limit as the memory kernel collapses to a Dirac function. Specifically, provided sufficiently many directions in the phase space are stochastically forced, we show that there is a unique stationary measure to which the system converges, in a suitable Wasserstein distance, at exponential rates independent of the decay of the memory kernel. We then prove the convergence of the statistically steady states to the unique invariant probability of the classical stochastic reaction-diffusion equation in the desired singular limit. As a consequence, we establish the validity of the small memory approximation for solutions on the infinite time horizon.

Peng's Maximum Principle for Stochastic Delay Differential Equations of Mean-Field Type

Schedule: July 8 14:30-15:00 Room 313

Federica Masiero

Milano-Bicocca University, Italy

Co-Author(s): Giuseppina Guatteri, Lukas Wessels

Abstract:

We extend Peng's maximum principle to the case of stochastic delay differential equations of mean-field type. More precisely, the coefficients of our control problem depend on the state, on the past trajectory and on its expected value. Moreover, the control enters the noise coefficient and the control domain may be non-convex. Our approach is based on a lifting of the state equation to an infinite dimensional Hilbert space that removes the explicit delay in the state equation. The main ingredient in the proof of the maximum principle is a precise asymptotic for the expectation of the first order variational process, which allows us to neglect the corresponding second order terms in the expansion of the cost functional.

Interpretation of stochastic primitive equations with relaxed hydrostatic assumption as a higher order approximation of 3D stochastic Navier-Stokes

Schedule: July 8 17:00-17:30 Room 313

Antoine Moneyron

Inria Rennes, France

Co-Author(s): Arnaud Debussche, Etienne Memin, Antoine Moneyron

Abstract:

We investigate the convergence of solutions of a stochastic representation of the three-dimensional Navier-Stokes equations to those of their primitive equations counterpart. Our analysis covers both weak and strong convergence regimes, corresponding respectively to rigid-lid and fully periodic boundary conditions. Furthermore, we explore the impact of relaxing the hydrostatic assumption in the stochastic primitive equations by retaining martingale terms as deviations from hydrostatic equilibrium. This modified model, obtained through a specific asymptotic scaling accessible only within the stochastic framework, captures non-hydrostatic effects while remaining within the primitive equations formalism. The resulting generalized hydrostatic model has been shown to be well-posed when the additional terms are regularized using a suitable filter for divergence-free noises under suitable assumptions. Within this setting, we demonstrate that the model provides a higher-order approximation of the 3D Navier-Stokes equations for appropriately scaled noises.

Invariant measures for the open KPZ equation

Schedule: July 9 14:30-15:00 Room 313

Tommaso Rosati

University of Warwick, England

Co-Author(s): Alex Dunlap and Yu Gu

Abstract:

We provide an analytic proof of celebrated relative density formulas of the invariant measures of the open KPZ equation with respect to white noise. The proof relies on a Girsanov transform, a time reversal and a subtle use of the theory of regularity structures to reconstruct the force of the solution to the KPZ equation at the boundary of the domain. This is joint work with A. Dunlap and Y. Gu.

Mass generation for the $O(N)$ Linear Sigma Model in the large N limit

Schedule: July 9 17:30-18:00 Room 313

Scott A Smith

Academy of Mathematics and Systems Sciences, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Matias Delgadino

Abstract:

This talk will focus on the $O(N)$ Linear Sigma Model on $\mathbb{R}^2$ under a scaling dictated by the formal $1/N$ expansion. We show that in the large N limit, correlations decay exponentially fast, where the acquired mass decays exponentially in the inverse temperature. In fact, each marginal converges to a massive Gaussian Free Field (GFF) on $\mathbb{R}^2$, quantified in the 2-Wasserstein distance with a weighted $H^1(\mathbb{R}^2)$ cost function. In contrast to prior work on the torus via parabolic stochastic quantization, our results hold without restrictions on the coupling constants, allowing us to also obtain a massive GFF in a suitable double scaling limit. Our proof combines the Feyel-Ustunel extension of Talagrand's inequality with some classical tools in Euclidean Quantum Field Theory.

On the density of the supremum of nonlinear SPDEs

Schedule: July 10 9:00-9:30 Room 313

Alexandra Stavrianidi

University of Munster, Germany

Co-Author(s): G. Karali, K. Tzirakis, P. Zouboulglou

Abstract:

The existence and regularity of densities for the supremum of stochastic processes is a classical problem in probability theory. While such questions are well understood for several Gaussian processes, much less is known for nonlinear stochastic partial differential equations. In this talk, I will present joint work with G. Karali, K. Tzirakis, and P. Zouboulglou establishing the existence of a density for the supremum of solutions to a class of nonlinear SPDEs in one spatial dimension driven by space time white noise. The class includes the nonlinear stochastic heat equation on a bounded domain with Dirichlet or Neumann boundary conditions. The proof relies on Malliavin calculus and a Bouleau Hirsch type criterion adapted to suprema of random fields.

Critical stationary fluctuations in reaction--diffusion processes

Schedule: July 9 14:00-14:30 Room 313

Kenkichi Tsunoda

Kyushu University, Japan

Co-Author(s): L. Cardoso, C. Landim, K. Tsunoda

Abstract:

We study stationary fluctuations at criticality for a one-dimensional reaction--diffusion process combining symmetric simple exclusion dynamics with Glauber-type spin flips. The strength of the Glauber interaction is tuned to the critical regime in which the quadratic term in the effective potential vanishes. Focusing on the stationary distribution, we show that the total magnetization scaled by $n^{3/4}$ exhibits non-Gaussian fluctuations.

Kac's program for the Landau equation

Schedule: July 9 17:00-17:30 Room 313

Zhenfu Wang

Peking University, Peoples Rep of China

Co-Author(s): Xuanrui Feng

Abstract:

We study the derivation of the spatially homogeneous Landau equation from the mean-field limit of a conservative N -particle system, obtained by passing to the grazing limit on Kac's walk in his program for the Boltzmann equation. Our result covers the full range of interaction potentials, including the physically important Coulomb case. This provides the first resolution of propagation of chaos for a many-particle system approximating the Landau equation with Coulomb interactions, and the first extension of Kac's program to the Landau equation in the soft potential regime. The convergence is established in weak, Wasserstein, and entropic senses, together with strong L^1 convergence. To handle the singularity of soft potentials, we extend the duality approach of Bresch-Duerinckx-Jabin and establish key functional inequalities, including an extended commutator estimate and a new second-order Fisher information estimate.

Convergence rate of lattice approximations for reflected stochastic partial differential equation

Schedule: July 10 9:30-10:00 Room 313

BIN XIE

Shinshu University, Japan

Abstract:

We investigate the convergence rate of a lattice approximation scheme for a reflected stochastic partial differential equation (SPDE) driven by Gaussian space-time white noise, which is viewed as an infinite-dimensional Skorohod problem. We establish the rate of $L^p(\Omega)$ -convergence for the approximations under Lipschitz continuous condition. Our approach is based on a detailed analysis of the corresponding deterministic parabolic obstacle problem via penalization methods.

Remarks on the three-dimensional Navier-Stokes equations with Lions' exponent forced by space-time white noise

Schedule: July 9 15:00-15:30 Room 313

Kazuo Yamazaki

University of Nebraska-Lincoln, USA

Abstract:

Navier-Stokes equations forced by space-time white becomes singular in a way that in all dimensions equal to or higher than two, the product of the nonlinear term becomes ill-defined. In case dimension is two, Da Prato-Debussche proved its global solution theory using explicit knowledge of invariant measure. More recently, Hairer-Rosati developed a new way to prove its global solution theory without relying on invariant measure. We apply the latter approach to the three-dimensional Navier-Stokes equations forced by space-time white noise and energy-critical diffusion; despite the absence of any knowledge of its invariant measure, we prove its global solution theory.

From particles via fluctuating hydrodynamics to gradient flows: Rigorous error estimates

Schedule: July 9 16:30-17:00 Room 313

Johannes Zimmer

TU Munich, Germany

Co-Author(s): Nicolas Dirr and Zhengyan Wu

Abstract:

The aim is to learn gradient flow evolution from underlying particle models. Specifically, we will discuss how the mobility of the thermodynamic evolution operator of suitable diffusive processes can be learned from particle data. Results will consider the case where the evolution is of Wasserstein gradient flow type. The central tool is a stochastic partial differential equation of fluctuating hydrodynamics type, which will be introduced in the talk. As rigorous result, error estimates for the mobility associated with the simple exclusion process are presented. Methodologically, this approach relies on the fact that fluctuating hydrodynamics can be seen as thermodynamically correct stochastic perturbation of a deterministic gradient flow.

Special Session 169 : Inverse problems arising in partial differential equations and mathematical physics

Organizer(s): Mengni Li

Introduction: Inverse problems involve the reconstruction of quantities of interest from indirect observations and are crucial in various applications such as physics, engineering, and medical imaging. This session will focus on inverse problems arising in partial differential equations and mathematical physics. Researchers in this field will gather to discuss their recent advancements and share insights on current challenges and future directions.

Asymptotic behavior of the Becker-DePoli-Henzl ring equations with fixed monomer concentration

Schedule: July 7 13:30-14:00 Room 641

Inmaculada Benitez Berral

Universidad de Granada, Spain

Co-Author(s): Prasanta Kumar Barik, Jos{\\}e A. Ca{\\}nizo

Abstract:

The Becker-Deuring equations, introduced by Becker and Deuring (1935), are a classical model for coagulation and fragmentation processes, describing how clusters of particles grow or break apart over time. They arise in a wide range of applications, including phase transitions, condensation phenomena, and aggregation processes in biological systems. While significant research has focused on the nonlinear case, including the study of metastable states by Penrose (1989) and the exponential convergence results in the subcritical case by Cañizo & Lods (2013), in this talk, we focus on the linear Becker-Deuring equations, corresponding to the case where the concentration of monomers is kept constant. In this setting, the evolution of the cluster densities $c_i(t)$ is governed by $\frac{d}{dt}c_i(t) = W_{i-1} - W_i$, for all $i \geq 2$, where the fluxes W_i describe the balance between coagulation and fragmentation mechanisms. Although the total mass of the system is not conserved in this linear case, the equations admit explicit equilibrium solutions. We study the long-time behavior of solutions and show that they converge exponentially fast towards equilibrium under natural assumptions on the model coefficients. The analysis combines ideas from entropy methods (Kreer (1993)) and spectral theory, leading to quantitative estimates of the convergence rate in both subcritical and supercritical regimes.

On the Determination of an Anisotropic Conductivity from the Neumann-to-Dirichlet Map in a Semilinear Elliptic Equation

Schedule: July 6 13:30-14:00 Room 641

Elena Beretta

New York University Abu Dhabi, United Arab Emirates

Co-Author(s): Elisa Francini Dario Pierotti Eva Sincich

Abstract:

We study the inverse boundary value problem of detecting a non-uniform conductivity motivated by pacing-guided ablation in cardiac electrophysiology. At the stationary level, the transmembrane potential u in a region $\Omega \subset \mathbb{R}^3$ of cardiac tissue satisfies

$$-\nabla \cdot (\gamma \nabla u) + \alpha u^3 = 0 \quad \text{in } \Omega, \quad \gamma \nabla u \cdot \nu = g \quad \text{on } \partial\Omega,$$

where γ is an anisotropic conductivity tensor and α a nonlinear ionic response coefficient. The Neumann data g represent pacing currents, and the boundary values $u|_{\partial\Omega}$ correspond to invasive voltage measurements. Ischemic regions are modeled by a subdomain $D \subset \Omega$ where γ is piecewise constant. We address the inverse problem of determining γ from the Neumann-to-Dirichlet (NtD) map, assuming that α and D are known. To our knowledge, uniqueness in the case of NtD data with anisotropic conductivities in this nonlinear setting has not been analyzed in previous work. Using a first-order linearization around a nontrivial pacing current, we prove uniqueness for γ .

Context aware iterative graph Laplacian for industrial imaging

Schedule: July 6 14:00-14:30 Room 641

Florian Bossmann

Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Davide Bianchi, Wenlong Wang

Abstract:

Industrial imaging often suffers from highly noised and undersampled data. As such, many state-of-the-art reconstruction algorithms are not applicable and practitioners rely on simple heuristic methods often paired with a simplified physical model. To improve the reconstruction quality, iterative methods are a favorable choice. One such method is the iterative graph Laplacian, which iteratively solves

$$x_n = \arg \min_x \|Ax - b\|_2 + \lambda \|\Delta_{x_{n-1}} x\|_1$$

where $\Delta_{x_{n-1}}$ is a graph Laplacian matrix based on the previous solution x_{n-1} . The initial guess x_0 is obtained using any chosen reconstruction algorithm. This method has proven to outperform other iterative approaches since the data adaptive graph Laplacian $\Delta_{x_{n-1}}$ imitates the structure of the given solution. It can differentiate between desired and undesired features within the data. However, the above approach requires a decent starting guess x_0 with structural features close to the real solution. This is not always the case in industrial imaging. We present an updated version of the iterative graph Laplacian by adjusting the construction of $\Delta_{x_{n-1}}$. The new matrix is context-aware and responds to possible artifacts or anomalies in the given solution x_{n-1} . We use a null space projection to counter any undesired edges within the solution as well as a directional ℓ_1/ℓ_2 weight to detect blurred edges. We demonstrate the method on non-destructive testing and seismic exploration examples.

Optimization-free coefficient identification via matched asymptotics in periodic advection-diffusion-reaction problems

Schedule: July 6 14:30-15:00 Room 641

DMITRII CHAIKOVSKII

Shenzhen MSU-BIT University, Peoples Rep of China

Co-Author(s): Dmitrii Chaikovskii, Ye Zhang, Aleksei Liubavin

Abstract:

We address forward analysis and inverse coefficient recovery for reaction-diffusion-advection models with time-periodic forcing in the singularly perturbed setting where diffusion is small and solutions develop a sharp moving front. Using matched asymptotic expansions, we construct a uniformly valid periodic approximation that resolves both the outer solution away from the front and the inner transition layer governing the front dynamics. The approximation yields explicit formulas for the leading-order profile and for the front location, and we provide rigorous error bounds. Building on this asymptotic surrogate, we develop two fast identification strategies: one for spatially heterogeneous coefficients and one for time-varying coefficients. In both cases, the inverse problem is reduced to a regularized least-squares fit involving readily measurable features (e.g., local gradients and front motion), eliminating iterative PDE-constrained optimization and significantly reducing computational cost. We prove stability and obtain convergence rates. Computational experiments confirm that the method recovers unknown coefficients accurately and robustly across a range of parameter regimes and noise levels, making it suitable for rapid calibration in environmental, biological, and engineering applications.

Large-Scale Model-Based 3D Image Reconstruction for Raster-Scan Optoacoustic Mesoscopy

Schedule: July 7 14:00-14:30 Room 641

Lena Dunst

German Electron Synchrotron (DESY), Helmholtz Imaging, Germany

Co-Author(s): Martin Burger

Abstract:

Optoacoustic mesoscopy is a biomedical imaging technique that provides images of the microvasculature of the skin. The skin tissue is illuminated with a short laser light pulse. Due to the optoacoustic effect this results in the generation of pressure waves, which leads to the inverse problem of reconstructing an image, representing the absorption properties of the tissue, from ultrasound measurements. We focus on a spherically focused ultrasound transducer performing a raster-scan on the skin surface and use a model-based image reconstruction approach. It consists of computing the forward model matrix describing the measurement process and using variational regularization to solve an optimization problem incorporating the forward model. A main challenge of the model-based reconstruction approach for 3D images is the excessive memory demand and the computation time. We reduce both by exploiting the symmetry of the ultrasound transducer and using a stochastic proximal gradient algorithm for iterative image reconstruction. In each iteration we randomly choose a certain number of model matrix rows and corresponding signal values for which we perform a gradient descent step on the data fidelity term and a proximal step on the regularization term. Furthermore, we use Langevin sampling to enable Bayesian uncertainty quantification.

Characterizing the detailed balance property by means of measurements in linear chemical systems

Schedule: July 7 14:30-15:00 Room 641

Eugenia Franco

University of Bonn, Germany

Co-Author(s): B. Kepka, J.J.L. Velazquez

Abstract:

The question that we address during this talk is whether it is possible to determine if a linear chemical system satisfies the detailed balance property using measurements. The property of detailed balance is a property of the chemical rates of chemical systems and it has an important physical meaning: active systems are modeled by equations that do not satisfy the detailed balance property, while passive systems are modeled by equations that satisfy the detailed balance property. We assume that the chemical rates of the reactions in systems are not known and we assume that we can access information on the system via some measurements. A measurement $R_{ij}(t)$ is the concentration of the substance i at time $t > 0$ after the injection of a substance j at time $t = 0$. We obtain a condition involving reciprocal measurements (i.e. $R_{ij}(t)$ and $R_{ji}(t)$) that is necessary, but not sufficient for the detailed balance condition to hold in the network. Moreover, we prove that this necessary condition is also sufficient if a topological condition is satisfied, as well as a stability property that guarantees that the chemical rates are not fine tuned.

Qualitative Experimental Design: an application in math biology

Schedule: July 6 16:30-17:00 Room 641

Kathrin Hellmuth

California Institute of Technology, USA

Co-Author(s): Christian Klingenberg, Qin Li, Min Tang

Abstract:

Experimental design determines the quality of available data and often has a strong effect on the well- or ill-posedness of an inverse problem. The classical optimal experimental design methodology rephrases the task of finding a design that yields informative data as an optimization problem that minimizes uncertainty of the reconstruction. In this talk, we want to extend this methodology to what we call qualitative experimental design. By relaxing the optimality to a sufficiency requirement, we concentrate on finding suitable designs that yield data which is sensitive w.r.t. the unknown parameter and thus allows its inference - at least locally. This opens a new methodological toolbox, and we lay out two strategies: \item some theoretical well-posedness proofs are constructive and rely on the design of suitable measurements. Possibly after discretization, these constructions can be translated to the practical setting in a relaxation-of-theory. \item a more generally applicable approach samples designs according to a sensitivity based distribution derived from matrix sketching. This method shall be investigated on an easy toy system, the potential reconstruction problem related to the stationary Schroedinger equation. We shall demonstrate both approaches on an inverse problem from kinetic PDEs related to bacterial chemotaxis.

Inverse Source Problems for Navier-Stokes Equations

Schedule: July 7 8:00-8:30 Room 641

Khonatbek Khompysh

Al-Farabi Kazakh National University, Kazakhstan

Abstract:

This paper talk I will discuss on unique solvability of some inverse source problems for the Navier-Stokes equations. The inverse problem consists in recovering a time-dependent source coefficient (intensity of external forces) from additional information on the velocity field given in an integral form over a spatial domain. We investigate this problem in three settings: the linear case, the nonlinear case, and a special case of the right-hand side. For the linear problem, we establish global-in-time existence, uniqueness, and stability results for both weak and strong solutions under suitable assumptions on the data. For the nonlinear problem, we consider this in two- and three-dimensional cases and prove the local-in-time (for sufficiently small data) existence and uniqueness of strong solutions. In addition, we analyze a special case of the right-hand side that allows to improve these results, in particular, in the two-dimensional case we prove the global-in-time unique solvability of the nonlinear problem.

Inverse problems for a nonlinear dynamical Schrödinger operator with magnetic potential

Schedule: July 6 17:00-17:30 Room 641

Boya Liu

North Dakota State University, USA

Co-Author(s): Mandeep Kumar, Manmohan Vashith

Abstract:

In this talk we discuss two inverse problems concerning a nonlinear dynamical Schrödinger operator with magnetic potential. We show that the Dirichlet-to-Neumann map determines the nonlinear coefficients uniquely. We shall consider both the full data and the partial data setting. In particular, with the assumption that the coefficients are known near the boundary, measurements are made on arbitrarily small sets of the lateral boundary of a space-time.

On the Robustness of Adaptive Eigenspace Inversion for Inverse Problems

Schedule: July 7 15:00-15:30 Room 641

Nasrin Nikbakht

University Of Auckland, New Zealand

Co-Author(s): Nasrin Nikbakht, Dr Marie Graff, Dr Melissa Tacy

Abstract:

This talk addresses the robustness of the Adaptive Eigenspace Inversion (AEI) method for inverse problems arising in partial differential equations. Such problems frequently involve the reconstruction of unknown parameters from noisy measurements, where stability and reliability are critical challenges. A revised framework is proposed by re-examining two key regularisation mechanisms. The number of eigenfunctions is selected using a sensitivity-based criterion, ensuring that only the most influential modes contribute to the reconstruction process. In parallel, the diffusivity cancellation parameter is analysed and shown to play a central role in stabilising the method, leading to the identification of an effective choice. Morozov's discrepancy principle is further incorporated to guide the adaptation process in the presence of data uncertainty. The resulting approach, termed adaptive- ε ASI, demonstrates improved stability and efficiency. Numerical experiments highlight its advantages over the original AEI method and standard techniques such as Tikhonov regularisation.

Stability of inverse problems arising from wave equations of Magnetic Schrodinger operators

Schedule: July 6 17:30-18:00 Room 641

Hadrian Quan

University of California Santa Cruz, USA

Co-Author(s): Boya Liu, Teemu Saksala, Lili Yan

Abstract:

I will present recent work regarding Holder stability estimates for two inverse problems arising from the wave equation associated to a Magnetic Schrodinger operator on a simple Riemannian manifold. The first such inverse problem is the question of stably recovering a non-negative electric potential, and the solenoidal part of a magnetic potential from measured Neumann boundary observations; the second problem similarly studies the question of stably recovering such potentials from the boundary spectral data of the associated Magnetic Schrodinger operator. I will discuss the connection between these two problems, and the technical issues introduced by the magnetic potential.

Regularization and discretization in the reconstruction for elliptic inverse problems

Schedule: July 6 15:00-15:30 Room 641

Luca Rondi

Universit  degli Studi di Pavia, Italy

Abstract:

We consider elliptic inverse problems such as the electrical impedance tomography or the determination of inhomogeneities by scattering measurements. We employ a variational approach for the reconstruction. Due to severe ill-posedness, it is needed to add to our minimization problem a regularization, for example of Tikhonov-type. The discretization used for the numerical implementation may also be another important cause of instability, which is often overlooked. We investigate how to handle simultaneously the regularization and the discretization so that the solution to the corresponding regularized and discrete minimization problem is a good approximation of the solution to the inverse problem.

Lipschitz Stability for Polyhedral Elastic Inclusions from Partial Data

Schedule: July 6 15:30-16:00 Room 641

Eva Sincich

University of Trieste, Italy

Co-Author(s): Andrea Aspri, Elena Beretta, Elisa Francini, Antonino Morassi, Edi Rosset, Sergio Vessella

Abstract:

We deal with the inverse problem of determining a polyhedral inclusion compactly contained in an elastic body from boundary measurements of traction and displacement taken on an open portion of the boundary. Both the inclusion and the body are made of homogeneous isotropic material. Under suitable assumptions on the geometry of the unknown inclusion, we prove a constructive Lipschitz stability estimate from the local Dirichlet-to-Neumann map. The main tools of our approach are quantitative estimates of unique continuation, the construction of singular solutions to the $\text{Lam}\backslash\{e\}$ system, a boundary formula for the Gateaux derivative of the Dirichlet-to-Neumann map with respect to a deformation homotopy, and the determination of a lower bound of this derivative using, among other tools, the Rongved biphas fundamental solution for the $\text{Lam}\backslash\{e\}$ system.

A Calderon Problem for the Dirac Operator

Schedule: July 7 8:30-9:00 Room 641

Carlos Valero

Instituto de Ciencias Matematicas (ICMAT), Spain

Abstract:

We consider on a spin manifold with boundary the twisted Dirac operator D_A with local boundary conditions, possibly coupled to a unitary connection A . For suitable values of m , we define an analogue of the Dirichlet-to-Neumann map corresponding to $D_A - m$, which we call the boundary conjugation (BC) map. By computing its symbol in dimensions $n \geq 3$, we show that the BC map determines the infinite-order jet of the metric and connection on the boundary in the case $m \neq 0$, when the conformal symmetry of the Dirac equation is broken. We go on to show that a real-analytic Riemannian manifold and twisted spin connection can be recovered from the BC map. Similar results hold in dimension 2 when the auxiliary connection A is absent.

Inverse scattering of the relativistic Schrödinger operator at a fixed energy

Schedule: July 6 18:00-18:30 Room 641

Yiran Wang

Emory University, USA

Abstract:

We consider the scattering of relativistic Schrödinger operators which are perturbations of the fractional Laplacian. For polyhomogeneous potentials decaying at infinity, we show that the asymptotics of the potential can be recovered from the scattering matrix at a fixed energy. This talk is based on a joint work with G. Uhlmann.

Inverse Problems for the Burgers Equation in Degenerate Domains

Schedule: July 7 9:00-9:30 Room 641

Madi Yergaliyev

Institute of mathematics and mathematical modeling, Kazakhstan

Abstract:

Let us consider a nonlinearly degenerate domain whose spatial boundaries are determined by time-dependent functions that coincide at the initial moment. In this domain, we investigate inverse problems for the Burgers equation under various combinations of unknown functions and boundary conditions. It is shown that, due to the degeneracy of the domain, the solvability of the proposed inverse problems requires additional conditions. The main objective of this work is to determine conditions under which these inverse problems are uniquely solvable.

Convergence analysis for a coefficient identification problem

Schedule: July 7 9:30-10:00 Room 641

Wensheng Zhang Zhang

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Co-Author(s): Huimin Huang

Abstract:

In this talk, we consider the convergence rate for Tikhonov regularization of the problem of identifying the coefficient in acoustic wave equation in the frequency-domain. We assume that the imprecise measurement data in a subdomain is known with a measurement error of level. First we propose to regularize this coefficient identification problem by minimizing a special functional. Then the characters of the functional are investigated. Finally, we obtain the convergence rate for the Tikhonov regularized solution under an easily satisfied source condition.

Forward and inverse problems for the BGK model with in-flow boundary condition

Schedule: July 6 18:30-19:00 Room 641

Hanming Zhou

University of California Santa Barbara, USA

Co-Author(s): Ru-Yu Lai, Hanming Zhou

Abstract:

In this talk, we will discuss the Bhatnagar-Gross-Krook (BGK) equation with in-flow boundary condition in a smooth bounded domain. First, we show that the BGK model linearized around a global Maxwellian admits a unique solution with some weighted L^∞ bound if the initial data and boundary condition are small perturbation around the global Maxwellian. Second, we investigate unique reconstruction of the collision frequency of the BGK equation from the albedo operator, which maps from the in-flow density to the out-flow density. We utilize the linearization technique and highly concentrated in-flow density to infer the velocity-independent collision frequency. The talk is based on joint work with Ru-Yu Lai.

Special Session 172 : Stochastic and geometric analysis on manifolds and metric measure spaces

Organizer(s): Kazuhiro Kuwae , Xiangdong Li , Asuka Takatsu

Introduction: Since the middle of 1970s, stochastic geometric analysis has achieved a great success in the mathematics research, for examples, the probabilistic proof of the Hörmander hypoellipticity theorem, the probabilistic proof of the Atiyah-Singer index theorem of the Dirac operator, and stochastic analysis and geometry on path and loop spaces. During the last thirty years, the optimal transportation theory, in particular, the gradient flow theory on the Wasserstein space of probability measures, has provided a new insight to study various problems in the Monge-Ampère equation, geometric PDEs, fluid hydrodynamics and has important applications in statistical mechanics and information theory. More recently, inspired by the works of M. Gromov, S. Amari and F. Otto, J. Lott, K.T. Sturm and C. Villani have developed the synthetic geometric analysis on metric measure space with curvature-dimension condition. Furthermore, progress is being made not only in spaces with Riemannian structures but also in spaces grounded in Lorentzian structures and in generalizations based on sub-Riemannian structures. In light of this current state, this session will feature talks by a wide range of leading researchers in manifolds, measure-metric spaces, and applications in image processing, aiming to promote cross-disciplinary advancement in this field.

Nonlinear gradient flows in spacetime geometry

Schedule: July 9 13:30-14:00 Room 639

Mathias Braun

EPFL, Switzerland

Abstract:

Recent work in optimal transport and metric geometry has opened new perspectives on spacetime geometry, uncovering deep connections with nonlinear elliptic PDEs, including Lorentzian variants of the p -Laplacian. In this talk, I will first outline these ideas and then present recent progress towards a metric theory of gradient flows in Lorentzian signature.

Stochastic perturbation of geodesics on the space of Riemannian metrics

Schedule: July 9 15:00-15:30 Room 639

Ana Bela Cruzeiro

Instituto Superior Tecnico, Portugal

Co-Author(s): Ali Suri

Abstract:

The evolution equation on the manifold of Riemannian metrics for the action functional associated with the L2 stochastic kinetic energy is derived.

Large deviations for small noise hypoelliptic diffusion bridges on sub-Riemannian manifolds

Schedule: July 9 16:30-17:00 Room 639

Yuzuru Inahama

Kyushu University, Japan

Abstract:

In this talk we discuss a large deviation principle of Freidlin-Wentzell type for pinned hypoelliptic diffusion measures associated with a natural sub-Laplacian on a compact sub-Riemannian manifold. To prove this large deviation principle, we use rough path theory and manifold-valued Malliavin calculus.

On Morrey's inequality over $\mathrm{RCD}(K, N)$ -spaces

Schedule: July 9 18:00-18:30 Room 639

Kazuhiro Kuwae

Fukuoka University/Department of Applied Mathematics, Japan

Co-Author(s): Jun Kitagawa

Abstract:

I will talk about a Morrey inequality in the framework of $\mathrm{RCD}(K, N)$ -spaces for $K \in \mathbb{R}$ and $N \in [1, +\infty[$.

Asymptotics of the Nonlocal Perimeter in Grushin Spaces

Schedule: July 9 14:00-14:30 Room 639

Huaiqian Li

Tianjin University, Peoples Rep of China

Abstract:

We investigate the fractional s -perimeter relative to a bounded domain Ω in the Grushin space, a typical model of sub-Riemannian manifolds that generally lack a group structure. On the one hand, we establish a limiting formula for the s -perimeter as $s \rightarrow 0^+$, imposing no regularity assumptions on the boundary of Ω . On the other hand, we provide a converse under a mild boundary condition that allows for domains with highly irregular (e.g., fractal) boundaries. Our results significantly weakens the typical Lipschitz or $C^{1,\alpha}$ regularity required in existing literature. The proofs exploit intrinsic properties of the Grushin heat semigroup, thereby circumventing tools such as the L^∞ -Liouville property used in earlier Riemannian settings.

On the W -entropy on Riemannian manifolds, metric measure spaces, Clifford algebra and quantum Markov semigroups

Schedule: July 9 17:00-17:30 Room 639

Xiang-Dong Li

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

In 2002, G. Perelman proved the monotonicity of the W -entropy for the Ricci flow. Since then, the W -entropy has been studied for various geometric flows on Riemannian manifolds. In this talk, I'll present some recent results on the study of the W -entropy on Riemannian manifolds, metric measure spaces, Clifford algebra and quantum Markov semigroups.

Non-adapted coupling of sub-Riemannian diffusions

Schedule: July 9 14:30-15:00 Room 639

Robert Neel

Lehigh University, USA

Co-Author(s): Liangbing Luo

Abstract:

We describe the classical Markov couplings of Riemannian Brownian motions and how these natural constructions fail in sub-Riemannian geometry, even for the simplest case of the Heisenberg group. After reviewing the situation, we describe an improvement and extension of recent constructions of non-adapted reflection couplings on sub-Riemannian model spaces by Banerjee-Gordina-Mariano and Ben-El-Mechaieq. Moreover, this construction is relatively simple and geometrically appealing, being based on global symmetries of the underlying spaces.

Nonlinear heat flow

Schedule: July 9 8:30-9:00 Room 639

Shin-ichi Ohta

University of Osaka, Japan

Abstract:

This talk will be a review of nonlinear heat flow on Finsler manifolds and metric measure spaces.

Dissipative Hamiltonian structure of the Vlasov-Fokker-Planck equation

Schedule: July 10 8:30-9:00 Room 639

Sangmin Park

California Institute of Technology, USA

Abstract:

The Vlasov-Fokker-Planck equation (VFP) describes the evolution of the probability density of the position and velocity of particles under the influence of external confinement, interaction, friction, and stochastic force. It is well-known that this equation can be formally seen as a dissipative Hamiltonian system in the Wasserstein space of probability measures. Moreover, the geometric structure has possible connections to the conjectured optimal convergence rates of underdamped Langevin Monte Carlo (ULMC), a sampling algorithm known to empirically outperform the (standard) Langevin Monte Carlo. This talk will focus on a time-discrete variational scheme for VFP which we introduce to more rigorously understand the geometric structure. We will begin by introducing the optimal transport problem and the Wasserstein distance, as well as the techniques of gradient flows which form the basis of our variational scheme. After highlighting the connections to ULMC, we will discuss how the proposed variational scheme is (i) consistent with the dissipative Hamiltonian structure, and (ii) (geodesically)-convex at each iteration.

Stability of weighted minimal hypersurfaces under a lower 1-weighted Ricci curvature bound

Schedule: July 9 9:00-9:30 Room 639

Yohei Sakurai

Saitama university, Japan

Co-Author(s): Yasuaki Fujitani

Abstract:

The aim of this talk is to present the validity of weighted Ricci curvature whose dimensional parameter is equal to 1 in view of extrinsic geometric analysis. It has been observed that the 1-weighted Ricci curvature exhibits singular behavior from the view point of the Cheeger-Gromoll splitting theorem and affine geometry. Recently, it has been also pointed out that its non-negativity is equivalent to the so-called substatic condition in the context of the Lorentzian geometry via conformal change of metric. After I review such developments, I will introduce several geometric consequences concerning stable weighted minimal hypersurfaces under a lower 1-weighted Ricci curvature bound. This talk is based on the joint work with Yasuaki Fujitani (University of Tokyo).

Disintegrated optimal transport for metric fiber bundles and their applications

Schedule: July 10 9:30-10:00 Room 639

Asuka Takatsu

The University of Tokyo, Japan

Co-Author(s): Jun Kitagawa

Abstract:

In this talk, I give a definition of the disintegrated Monge--Kantorovich metrics, which are a two-parameter family of metrics on subsets of Borel probability measures on general metric fiber bundles, and demonstrate their applications.

Gaussian processes under adapted Wasserstein distance

Schedule: July 10 9:00-9:30 Room 639

Ting Kam Leonard Wong

University of Toronto, Canada

Co-Author(s): Madhusoodan Gunasingam and Ting-Kam Leonard Wong

Abstract:

The adapted Wasserstein distance is a distance between stochastic processes. It is defined in terms of an adapted optimal transport problem that takes into account the flow of information in term. We consider (filtered) Gaussian processes for which explicit computations and their geometric properties have recently been developed. In particular, the adapted Wasserstein distance (with $p = 2$) can be expressed explicitly in terms of the Cholesky factors, and can be interpreted in terms of a constrained Procrustes problem. In this Gaussian setting, we discuss various properties of the adapted Wasserstein distance and also study the multi-causal barycenter.

Functional inequalities on the Riemannian path space

Schedule: July 9 17:30-18:00 Room 639

Bo Wu

Fudan University, Peoples Rep of China

Co-Author(s): Tianyu Wang

Abstract:

In this talk, we first review recent progress in stochastic analysis on Rieamnian path space. We prove an integration by parts formula on path space over a general non-compact Riemannian manifold with a skew symmetric torsion. Using this formula, we derive quasi regular $O-U/L^2$ Dirichelt forms as well as corresponding functional inequalities. This is joint work with Tianyu Wang.

From Schroedinger to Feynman and back

Schedule: July 9 15:30-16:00 Room 639

Jean-Claude Zambrini

GFM, FCUL and IST, Lisbon, Portugal

Co-Author(s): Qiao Huang

Abstract:

We shall present recent progress in the stochastic dynamical theory founded on Schroedinger's variational problem (1932). As suggested by him, it shares a number of qualitative properties with Quantum Mechanics and can also be regarded as a mathematically sound version of Feynman's path integral approach.

Lipschitz regularity of harmonic map heat flows into CAT(0) spaces

Schedule: July 9 9:30-10:00 Room 639

Hui-Chun Zhang

Sun Yat-sen University, Peoples Rep of China

Abstract:

In 1964, Eells and Sampson proved the celebrated long-time existence and convergence for the harmonic map heat flow into non-positively curved Riemannian manifolds. In 1992, Gromov and Schoen initiated the study of harmonic maps into CAT(0) metric spaces. It naturally motivates the study of the harmonic map heat flow into singular metric spaces. In the 1990s, Mayer and Jost independently studied convex functionals on CAT(0) spaces and extended Crandall-Liggett's theory of gradient flows from Banach spaces to CAT(0) spaces to obtain the weak solutions for the harmonic map heat flow into CAT(0) spaces. The weak solutions enjoy the favorable long-time existence, uniqueness and well-established long-time behaviors. It is a long-standing open question whether the weak solutions possess Lipschitz regularity. Very recently, by using elliptic approximation method, Lin, Segatti, Sire, and Wang proved the weak solutions are Lipschitz in space and $(1/2)$ -Hölder continuous in time, for a wide class of CAT(0) spaces. In this talk, we will introduce a complete answer to the question, showing that every weak solution of the harmonic map heat flow into CAT(0) spaces is Lipschitz continuous in both space and time. We also establish an Eells-Sampson-type Bochner inequality. This is based on a joint work with Xi-Ping Zhu.

Special Session 173 : Mathematical and Numerical Analysis on Nonlinear PDEs

Organizer(s): Hiroyuki Takamura , Ning-An Lai , Takiko Sasaki

Introduction: This special session is focused on nonlinear partial differential equations in both mathematical and numerical viewpoints. Our aim is to foster exchanges among researchers by providing a platform for sharing methodologies, motivations and perspectives. We are also seeking stimulate collaborations and advances on interconnected fields. More practically, for the mathematical analysis part, we are mainly interested in the blow-up, the existence and asymptotic behaviors of solutions of hyperbolic equations including lifespan estimates, but wide kinds of equations are also targeted. We do not only understand new results but also look for proofs with affinity to numerical analysis. Besides them, nonlinear discrete equations and related disciplines are considered in the numerical analysis part including discretization of nonlinear integrable systems, difference schemes and analysis for blowing-up problems, the direction of a bifurcating branch, stability of stationary solutions of nonlocal equations and the rescaling method for quenching problems.

Lifespan estimates for the semilinear wave equation with a forcing term

Schedule: July 7 9:00-9:30 Room 430

Meiirkhan B Borikhanov

Institute of Mathematics and Mathematical Modeling, Kazakhstan

Co-Author(s): H.Takamura, B.T. Torebek

Abstract:

We study the lifespan of solutions to a semilinear wave equation with a forcing term. Under suitable assumptions on the initial data and the external force, we derive upper and lower bounds for the maximal existence time of solutions. The analysis highlights how the forcing term influences blow-up behavior and modifies the classical lifespan estimates known for the unforced problem.

L_p - L_q estimates for evolution equations with damped oscillations

Schedule: July 7 13:30-14:00 Room 430

Marcello D'Abbicco

University of Bari, Italy

Co-Author(s): Marcelo Rempel Ebert

Abstract:

In this talk, we discuss $L^p - L^q$ estimates, with $1 \leq p \leq q \leq \infty$, for dissipative wave-type equations, under the assumption that the dissipation dampens the oscillations but it does not cancel them. We employ methods based on Fourier analysis, including the use of real Hardy space $H^1(\mathbb{R}^n)$ and stationary phase arguments to take into account of the dispersive nature of the equation.

Scattering and energy cascade for the 2D Klein-Gordon-Zakharov

Schedule: July 7 17:00-17:30 Room 430

Shijie Dong

Southern University of Science and Technology, Peoples Rep of China

Abstract:

We study the Klein-Gordon--Zakharov system in two spatial dimensions, an important model in plasma physics. For small, smooth, and spatially localized initial data, we establish the global existence of solutions and characterize their sharp long-time behavior, including sharp time decay, scattering, and growth of Sobolev norms. This is joint with Prof. Zihua Guo and Prof. Kuijie Li.

Global existence for a semilinear damped wave equation with certain positive initial displacement and negative initial velocity

Schedule: July 7 14:30-15:00 Room 430

Kazumasa Fujiwara

Ryukoku University, Japan

Co-Author(s): Vladimir Georgiev

Abstract:

In this talk, global existence for the Cauchy problem for a semilinear damped wave equation with positive initial displacement and negative initial velocity is investigated. In the classical theory, solutions are known to blow up if the sum of the mean values of the initial displacement and velocity is nonnegative, while global existence holds if the initial data satisfy a pointwise sign condition. However, it remains unclear whether solutions blow up in other cases. In this talk, a new condition on the initial data ensuring global existence is presented. Our approach is to show that the solution satisfies the classical global existence condition of Li and Zhou at some time. In particular, the solution is bounded by the initial displacement times a time-dependent amplification factor. This factor is shown to change sign at a certain time. The initial displacement and velocity are assumed to be given by a common polynomially decaying function multiplied by a positive constant and a negative constant, respectively.

On lifespan estimates for a discrete Fujita equation

Schedule: July 8 13:30-14:00 Room 430

Kohei Higashi

Musashino University, Japan

Abstract:

We study the lifespan of solutions to a discrete analogue of the semilinear heat equation with power nonlinearity, viewed as a discrete Fujita equation on the lattice. Previous work has shown that this model exhibits finite-time blow-up with the same Fujita critical exponent as in the continuous setting. We investigate how the lifespan depends on the size of small initial data and on the exponent relative to the Fujita critical exponent. We prove that, in both the subcritical and critical cases, the lifespan has the same order as that of the corresponding continuous problem.

On inverse scattering for time-decaying harmonic and repulsive potentials

Schedule: July 7 17:30-18:00 Room 430

Atsuhide Ishida

Tokyo University of Science, Japan

Abstract:

We study quantum inverse scattering for Schrödinger equations with time-dependent quadratic Hamiltonians. The unperturbed system contains either harmonic or repulsive quadratic potentials whose strength decays at a critical rate in time. This decay produces scattering states that differ from both the free and time-independent cases. For real-valued interaction potentials satisfying suitable spatial decay conditions, the existence of wave operators has been established in previous work, and the associated scattering operator is well defined. The main result presented here proves uniqueness in inverse scattering: the interaction potential is uniquely determined by the scattering operator. In the harmonic case, scattering arises despite the confining nature of the quadratic potential. In the repulsive case, the time decay modifies the long-time behavior and allows decay comparable to the long-range class in the Stark effect, while remaining short-range within this framework.

The lifespan of solutions of semilinear wave equations with characteristic weights in two space dimensions

Schedule: July 7 8:30-9:00 Room 430

Masakazu Kato

Graduate School of Science, University of Hyogo, Japan

Co-Author(s): Hiroyuki Takamura, Kyouhei Wakasa

Abstract:

In this talk, we study the initial value problem for semilinear wave equations with characteristic weights in two space dimensions. Our purpose of this talk is to determine the critical exponent that separates the time global existence and non-existence of solutions and the sharp lifespan estimates. We classify the exponent and lifespan by the integral of higher-order moments of the initial positions and speeds.

Space-time decay of global solutions to a system of damped wave equations

Schedule: July 8 9:30-10:00 Room 430

Kosuke Kita

Hokkaido university, Japan

Abstract:

We consider the Cauchy problem for a weakly coupled system of semilinear damped wave equations in $\mathbb{R}^N$ ($N = 1, 2, 3$). We prove the global existence of mild solutions for sufficiently small initial data and derive weighted pointwise space-time decay estimates. These estimates provide a refined description of the decay of each component in time and space. In particular, depending on the nonlinearity exponent relative to the Fujita critical exponent, the solutions exhibit different decay patterns, including an asymmetric regime in which one component decays more slowly and a logarithmic correction in the borderline case. The proof is based on weighted L^∞ -estimates for the linear damped wave equation.

Global Weak Solutions to Nonlinear Wave Equations with Damping under Fractional Derivative Control

Schedule: July 8 9:00-9:30 Room 430

Hideo Kubo

Hokkaido University, Japan

Co-Author(s): Bushra Nisar

Abstract:

In this talk we present a result on the initial-boundary value problem for the wave equation with nonlinear damping and source terms prescribed the nonhomogeneous Neumann boundary condition involved time fractional derivative of solution. In the pioneering work of Professors Georgiev and Todorova (1994), existence of global weak solution exists for homogeneous Dirichlet boundary value problem, provided the damping term is dominated to the source term in some sense. On the other hand, a recent work of Mbodje(2004) consider the linear wave equation with the time fractional Neumann boundary condition in one space dimension. Our purpose is simply to extend the latter result to the nonlinear setting as in the former work.

Asymptotic expansions of global solutions to the convection-diffusion equation with critical dissipation

Schedule: July 7 18:30-19:00 Room 430

Ryunosuke Kusaba

Tohoku University, Japan

Co-Author(s): Taiki Takeuchi

Abstract:

This talk is concerned with the large-time behavior of global solutions to the Cauchy problem for the convection-diffusion equation with critical dissipation. The existence, decay estimates, and the first and second order asymptotic expansions of global solutions are established by using maximal regularity estimates in the homogeneous Besov spaces. In addition, with the aid of the self-similar structures in the asymptotic profiles, the optimal decay rates of the global solutions and the optimal convergence rates for the first order asymptotic expansion are determined.

Wave type equations with perturbed derivatives

Schedule: July 7 18:00-18:30 Room 430

Sandra Lucente

Dipartimento Interuniversitario di Fisica, Bari University, Italy

Co-Author(s): Felisia Chiarello, Giovanni Girardi

Abstract:

We investigate semilinear wave-type equations that can be recast as wave equations with derivatives perturbed by zero-order terms. This framework covers several well-studied cases, including the scale-invariant wave equation. In this setting, we refine existing blow-up results for radial initial data with suitable decay, and identify conditions on the zero-order terms that govern the interplay between derivative perturbations, initial data size, and nonlinearity exponent.

Analytical and numerical results on the global bifurcation structure of a cell polarization problem

Schedule: July 8 15:00-15:30 Room 430

Tatsuki Mori

Musashino University, Japan

Co-Author(s): Tatsuki Mori

Abstract:

We investigate the global bifurcation structure of solutions for a nonlinear boundary value problem with a nonlocal constraint arising in a cell polarization model with mass conservation proposed by Mori, Jilkin, and Edelstein-Keshet. Regarding the shadow system of the stationary problem, a representation formula for the solutions and the global bifurcation diagrams have already been obtained. In this talk, we derive a representation formula for the solutions of the original problem and report on numerical simulations of its global bifurcation diagram. In particular, global bifurcation diagrams include secondary and imperfect bifurcation phenomena.

Blowing-up solutions of Klein-Gordon equations with gauge variant semilinear terms in FLRW spacetimes

Schedule: July 7 16:30-17:00 Room 430

Makoto Nakamura

The University of Osaka, Japan

Co-Author(s): Makoto Nakamura, Takuma Yoshizumi

Abstract:

Blowing-up solutions of Klein-Gordon equations with gauge variant semilinear terms are considered in Friedmann-Lemaître-Robertson-Walker spacetimes. Effects of spatial expansion or contraction on the solutions are studied through the scale-function and the curved mass.

Blow-up results for Nakao-type problems with time-dependent coefficients

Schedule: July 7 15:00-15:30 Room 430

Alessandro Palmieri

University of Bari, Italy

Co-Author(s): Yuequn Li

Abstract:

In this talk, I will discuss some blow-up results for a Nakao-type semilinear weakly coupled system. In particular, we consider the case when a wave equation is coupled with a damped wave equation with a time-dependent coefficient for the damping term. We investigate the influence of a scattering producing/scale-invariant damping term on the blow-up region for power nonlinearities and for derivative-type nonlinear terms.

Numerical quenching time for rescaling algorithm on nonlinear wave equations

Schedule: July 8 14:00-14:30 Room 430

Takiko Sasaki

Musashino University, Japan

Co-Author(s): Maiss\hat{a} Boughrara

Abstract:

The purpose of this talk is to establish numerical methods for computing quenching solutions of one space dimensional nonlinear wave equations with power nonlinearities. We consider a hybrid scheme based on a finite difference scheme and a rescaling technique to approximate the solution of nonlinear wave equation. To numerically reproduce the quenching phenomena, we propose a rule of scaling transformation, which is a variant of what was successfully used in the case of nonlinear parabolic equations. After having verified the convergence of our proposed schemes, we prove that solutions of those finite-difference schemes actually quench in the corresponding quenching times. Then, we prove that the numerical quenching time converges to the exact quenching time as the discretization parameters tend to zero. Several numerical examples that confirm the validity of our theoretical results are also offered.

Fractional dispersion phenomena in the Helmholtz equation

Schedule: July 7 9:30-10:00 Room 430

Nico Michele Schiavone

Polytechnic University of Madrid, Spain

Abstract:

We discuss the fractional dispersion of solutions to the Helmholtz equation with periodic scattering data. Under suitable rescaling, the interaction between different frequencies exhibits the same fluctuating behavior found in the Schrödinger equation. Since the Helmholtz equation represents the stationary form of various evolution equations, these phenomena appear to be a general feature of periodic scattering at the fractional scale. Our results are based on establishing an asymptotic fractional uncertainty principle for solutions to the Helmholtz equation. Joint work with Javier Canto (UPV/EHU) and Luis Vega (UPV/EHU, BCAM).

Discontinuous Galerkin Methods for the Incompressible Magnetohydrodynamic System with Navier-Type Boundary Conditions

Schedule: July 7 15:30-16:00 Room 430

Nour Seloula

University of Caen Normandie, France

Abstract:

In this talk, we introduce and analyze a discontinuous Galerkin method for the stationary incompressible magnetohydrodynamic system subject to Navier-type boundary conditions for both the velocity and the magnetic field. We establish a new discrete Sobolev inequality in the L^p setting, which plays a central role in the analysis, in particular for proving the well-posedness and convergence of the scheme. The existence and uniqueness of a discrete solution are obtained by means of the Banach fixed point theorem under a smallness assumption on the data. Furthermore, we derive a priori error estimates in a natural energy norm for both the velocity and the magnetic field. To the best of our knowledge, this is the first work providing a complete analysis of a discontinuous Galerkin method for the nonlinear coupled magnetohydrodynamic system with Navier-type boundary conditions imposed simultaneously on the velocity and the magnetic field.

Quenching of finite-difference solutions to nonlinear heat equations with non-local terms

Schedule: July 8 14:30-15:00 Room 430

Tetsuji Tokihiro

Musashino University, Japan

Co-Author(s): Takiko Sasaki

Abstract:

This talk investigates the quenching phenomenon for numerical solutions of nonlinear heat equations incorporating non-local terms. Quenching occurs when a solution remains bounded while its time derivative blows up in finite time - a behavior well-documented in continuous parabolic models but increasingly complex in discrete settings. We employ a finite-difference scheme to discretize the governing equations. A primary result of this work is the proof that discrete quenching always occurs whenever the continuous counterpart quenches. We also examine the convergence of the discrete quenching time to its continuous counterpart as the mesh size approaches zero. These results offer critical insights into the reliability of finite-difference methods for capturing singular behaviors in non-local nonlinear problems, ensuring that numerical artifacts do not obscure the underlying physical properties of the system.

Lifespan estimates of solutions for the semilinear parabolic equations

Schedule: July 8 8:30-9:00 Room 430

Berikbol Torebek

Institute of Mathematics and Mathematical Modeling, Kazakhstan

Abstract:

We will discuss lifespan estimates for blow-up solutions of semilinear parabolic equations on unbounded domains such as whole Euclidean space, half space and exterior domains. By using a suitable family of test functions, we obtain upper bounds for the lifespan of solutions. In some cases, we also derive lower bounds for the lifespan.

Lifespan of solutions to systems of semilinear wave equations in one space dimension

Schedule: July 7 8:00-8:30 Room 430

Kyouhei Wakasa

Muroran Institute of Technology, Japan

Co-Author(s): Soichiro Katayama

Abstract:

In this talk, we consider the systems of semilinear wave equations with multiple speeds in one space dimensions. We obtain the almost optimal lifespan estimate under some condition weaker than the null condition. This is a joint work with Professor Soichiro Katayama (The University of Osaka).

Recent progress on the semilinear damped wave equation with slowly decaying data

Schedule: July 7 14:00-14:30 Room 430

Yuta Wakasugi

Hiroshima University, Japan

Co-Author(s): Yuta Wakasugi

Abstract:

Consider the Cauchy problem for the semilinear damped wave equation $u_{tt} - \Delta u + u_t = |u|^p$ for $t > 0, x \in \mathbb{R}^n$. By the studies conducted from the 1990s to the early 2000s, it is known that, for smooth compactly supported initial data, the critical exponent is given by the so-called Fujita critical exponent ($p = 1 + 2/n$). Subsequently, the critical exponent problem with non-compactly supported or slowly decaying (in general not in L^1) initial data has also been studied. In this talk, we review previous studies and present some recent progress on this topic.

Physical space approach to bilinear estimates and applications to wave and dispersive equations

Schedule: July 8 8:00-8:30 Room 430

Yi Zhou

Fudan University, Peoples Rep of China

Abstract:

We develop a new bilinear estimate method based on a new div curl lemma. We can use our method to give alternative proof of low regularity local well posedness for dispersive equations, which previously rely on Bourgain space. We can also use our method to give new proof of global existence of classical solutions for nonlinear wave equations with small initial data. Moreover, we establish new results including the proof of Weiyue Ding's conjecture for periodic Schrodinger flow, the global well posedness in the critical Besov space of the skew mean curvature flow and the global well posedness in critical Sobolev space of Ishimori equations.

Special Session 175 : Modern Trends in Partial Differential Equations and General Relativity

Organizer(s): Anahit Galstyan , Makoto Nakamura , Karen Yagdjian

Introduction: This special session will focus on the latest developments in the mathematical analysis of Partial Differential Equations that arise in the context of General Relativity and Cosmology. The topics will include the representation and qualitative properties of the solutions of initial value and boundary value problems for linear and nonlinear PDEs in curved spacetimes, global existence, blowup of the solutions, numerical simulations, applications of new analytic and geometric methods, such as geometric measure theory and microlocal analysis, to tackle previously intractable problems in mathematical physics, etc. The session aims to provide a platform for leading researchers and junior scholars to discuss recent breakthroughs, new methods, and future directions in the field, fostering collaboration and the exchange of innovative ideas.

Competing time-dependent dissipation mechanisms in wave models: friction vs. viscoelastic damping

Schedule: July 9 8:00-8:30 Room 739

Halit Sevki Aslan

University of Sao Paulo, Brazil

Co-Author(s): Michael Reissig

Abstract:

We study the following Cauchy problem for the linear wave equation with both time-dependent frictional and viscoelastic damping terms:
$$\begin{cases} u_{tt} - \Delta u + b(t)u_t - g(t)\Delta u_t = 0, & (t,x) \in [0,\infty) \times \mathbb{R}^n, \\ u(0,x) = u_0(x), \quad u_t(0,x) = u_1(x), & x \in \mathbb{R}^n. \end{cases}$$
 Our goal is to derive decay estimates for higher-order energy norms of solutions to this problem. We focus on the interplay between the time-dependent coefficients in the frictional damping $b(t)u_t$ and viscoelastic damping $-g(t)\Delta u_t$, and their influence on the qualitative behavior of solutions. The analysis is based on the classification of the damping mechanisms and employs the WKB method in the extended phase space.

Propagators for the Klein--Gordon equation on asymptotically Minkowski spacetimes

Schedule: July 7 14:00-14:30 Room 739

Dean Baskin

Texas A&M University, USA

Co-Author(s): Moritz Doll, Jesse Gell-Redman

Abstract:

I will describe a way of constructing the causal and Feynman propagators on asymptotically Minkowski spacetimes for the Klein--Gordon equation with potentials that decay in space but not necessarily in time. In particular, this includes the possibility of the presence of bound states of the limiting spatial Hamiltonians. The proof rests on propagation of singularities estimates in all regions of infinity that are proved in the framework of Vasy's many-body work. This is joint work with Moritz Doll (Macquarie) and Jesse Gell-Redman (Melbourne).

Magnetic Uniform Resolvent Estimates

Schedule: July 7 14:30-15:00 Room 739

Piero D'Ancona

Sapienza University, Rome, Italy

Co-Author(s): Zhiqing Yin

Abstract:

A classical result due to Kenig, Ruiz and Sogge, states that the resolvent operator for the Euclidean Laplacian $(-\Delta - z)^{-1}$ is bounded from L_p to L_q for a certain range of indices p, q . The operator norm depends on the frequency z , as dictated by scaling, and it is actually independent of z for suitable values of p and q , hence the 'uniform' tag. In view of their applications to Spectral Theory, Harmonic Analysis and Nonlinear PDEs, it is interesting to extend these estimates to more general operators beyond the Laplacian. In this joint work with Zhiqing Yin we consider a general electromagnetic Laplacian and, under suitable decay assumptions on the potentials, we recover the same range of indices as in the free case. As an application, we deduce a 'magnetic' restriction estimate of Tomas-Stein type.

Dispersive estimates for wave type equations with time-dependent damping

Schedule: July 9 8:30-9:00 Room 739

Marcelo Ebert

University of Sao Paulo, Brazil

Co-Author(s): Halit Sevki Aslan

Abstract:

In this talk we discuss the Cauchy problem for a class of semilinear evolution equations with scale-invariant time-dependent dissipation
$$\begin{cases} u_t + L_w u + \frac{\mu}{1+t} u = f(u), & t > 0, \\ u(0, x) = 0, & x \in \mathbb{R}^n, \end{cases}$$
 where L_w is a Fourier multiplier operator defined by $L_w u = \mathcal{F}^{-1}(w(\xi)^2 \hat{u})$, $f(u) = |u|^\alpha$ or $f(u) = \Delta |u|^\alpha$, and $\mu > 0$, $\alpha > 1$ are constants. We prove global (in time) existence of small data solutions for $\alpha > \alpha_{\text{crit}}$, where the critical exponent α_{crit} depends on the choice of the operator L_w . More precisely, it corresponds to a Strauss-type exponent in the case of Boussinesq-type operators $w(\xi) = \sqrt{|\xi|^2 + |\xi|^4}$, while it becomes a Fujita-type exponent for plate-type operators $w(\xi) = |\xi|^\sigma$, $\sigma \geq 2$. The main tools to prove this result are Duhamel's principle, dispersive estimates of solutions of a family of parameter-dependent linear Cauchy problems with vanishing right-hand side and Banach's fixed point theorem.

Waves in the Reissner-Nordstrom space-time

Schedule: July 9 17:30-18:00 Room 739

Anahit Galstyan

University of Texas Rio Grande Valley, USA

Abstract:

We consider the propagation of waves in the Reissner-Nordstrom space-time, which is gaining mass and charge in the universe with accelerating expansion, namely, the solutions of the linear and semilinear Klein-Gordon equations. We have been able to prove the existence of global in-time small data solutions of semilinear Klein-Gordon equations in this spacetime.

Asymptotic stability of parallel flow of compressible viscoelastic system under local perturbation

Schedule: July 9 16:30-17:00 Room 739

Yusuke Ishigaki

Kwansei Gakuin University, Japan

Abstract:

In this talk, we deal with compressible viscoelastic system in an infinite layer. We discuss stability of parallel flow occurring by given external force. It is shown that the asymptotic stability of parallel flow holds under small local perturbation, provided that viscous coefficients are large and propagation speeds of sound and elastic waves are fast.

On the stability of Euler--Nordstrom System

Schedule: July 9 14:00-14:30 Room 739

Lavi Karp

Braude College of Engineering, Israel

Co-Author(s): U. Brauer

Abstract:

We study the global existence of classical solutions to the Euler--Nordstrom system, which incorporates a linear equation of state and a positive cosmological constant. The system can be written as a coupled system of wave equations: a semilinear wave equation for the Nordstrom gravitational field, whose source contains a fractional-power nonlinearity; and an acoustical equation, which is a quasilinear wave equation with nonlinearities involving first-order derivatives. We restrict attention to spatially periodic perturbations of the background metric and formulate the problem on the three-dimensional torus, working within the corresponding Sobolev spaces. The emphasis is on the scalar gravitational field equation. We also discuss related questions for the Euler--Poisson and Euler--Einstein systems. This is joint work with U. Brauer (Universidad Complutense Madrid).

Stability of t -periodic solutions to the optical fiber model describing EDFA effect

Schedule: July 7 15:30-16:00 Room 739

Naoyasu Kita

Kumamoto University, Japan

Abstract:

We consider the initial value problem to a nonlinear Schrödinger equation containing both linear amplification and cubic nonlinear dissipation. This model describes the evolution of pulses propagating through a special optical fiber providing the effect of erbium doped fiber amplifier (for short, EDFA). It is known that the nonlinear Schrödinger equation possesses a t -periodic uniform solution (t -PUS). In this talk, we discuss the stability of t -PUS under small perturbations in $H^1(\mathbb{T})$, where $\mathbb{T} = \mathbb{R}/2\pi\mathbb{Z}$. If time permits, the bifurcation of amplitude of the t -PUS will be discussed. By the bifurcation analysis, a t -periodic solution with curved amplitude is obtained, and it is possibly applied to the information transmission through an optical fiber

On the asymptotic behavior of the semilinear Schroedinger equation in the FLRW spacetime

Schedule: July 9 15:00-15:30 Room 739

Makoto Nakamura

The University of Osaka, Japan

Co-Author(s): Makoto Nakamura, Eiichi Sugimoto

Abstract:

The Cauchy problem for the semilinear Schroedinger equation is considered in one spatial dimension in the FLRW spacetime. The asymptotic behavior is classified based on the power of the semilinear term. The effect of spatial expansion and contraction is shown.

Strong instability of standing waves for a system of nonlinear Klein-Gordon equations with quadratic interaction

Schedule: July 7 15:00-15:30 Room 739

Masahito Ohta

Tokyo University of Science, Japan

Abstract:

We consider a system of nonlinear Klein-Gordon equations with quadratic interaction in two and three space dimensions. The strong instability of standing wave solutions is studied for the system without assuming the mass resonance condition.

The critical case for the EPDT equation

Schedule: July 9 9:30-10:00 Room 739

Alessandro Palmieri

University of Bari, Italy

Co-Author(s): Ning-An Lai, Hiroyuki Takamura

Abstract:

In this talk, we investigate the blow-up of local solutions to the semilinear Euler-Poisson-Darboux-Tricomi equation with a critical exponent of Strauss-type. By using a Kato-type comparison lemma for ODE, the Radon transform and Yagdjian's integral representation approach, we derive a blow-up result following the approach for the determination of the sharp upper bound estimates for the lifespan for the critical wave equation by Takamura-Wakasa [JDE, 2011].

Spatially weighted nonlinear wave equations in 1D and Li-Zhou theorem

Schedule: July 9 9:00-9:30 Room 739

Hiroyuki Takamura

Tohoku University, Japan

Co-Author(s): Ning-An Lai, Cui Ren, Takiko Sasaki

Abstract:

I will focus on one dimensional wave equations with spatially weighted nonlinear terms which include the equation arising from cosmology as a special case. The sharp lifespan estimates are given both from below and above, but it is remarkable that the proof of the blow-up part is closely related to Li-Zhou theorem on nonlinear classical damped wave equations in 1995.

Microlocal analysis of the non-relativistic limit of the Klein-Gordon equation

Schedule: July 7 13:30-14:00 Room 739

Andras Vasy

Stanford University, USA

Co-Author(s): Andrew Hassell, Qiuye Jia, Ethan Sussman

Abstract:

The non-relativistic limit for a Klein-Gordon equation, with electric and magnetic potential terms on a Lorentzian manifold, corresponds to a family of Lorentzian metrics for which, with respect to an appropriate spacelike foliation of the manifold, the speed of light tends to infinity. Concretely, we consider decaying, both in spacetime and as $c \rightarrow +\infty$, perturbations of the Minkowski metric, $-c^2 dt^2 + dx^2$, with spacetime decaying electric and magnetic potentials on $\mathbb{R}^{1,d}$; this is interesting already if the metric is just the c -dependent Minkowski metric. We give a complete and unified phase space analysis of the solution operators for the inhomogeneous wave equation as $c \rightarrow \infty$. In some regimes these tend to the Minkowski Klein-Gordon propagators, but in others (spatially low frequency) two copies of the Schrödinger propagator emerges, with electric and magnetic potentials, but on flat space, as expected from the standard physical treatment. Joint work with Andrew Hassell, Qiuye Jia and Ethan Sussman; the talk will emphasize the microlocal ingredients of the project, as in arXiv:2509.09518, see arXiv:2511.08724 for the applications.

On initial boundary value problems for the Maxwell-Schrodinger system

Schedule: July 9 14:30-15:00 Room 739

Takeshi Wada

Shimane University, Japan

Abstract:

In this talk, we study the initial-boundary value problem for the Maxwell-Schrödinger equations (MS) in a bounded or exterior domain $\Omega \subset \mathbb{R}^d$, $d = 2, 3$, with smooth boundary $\partial\Omega$. MS is a system of the Schrödinger equation with electro-magnetic potentials and the Maxwell equations written in terms of electro-magnetic potentials. Physically, this system describes the interaction between a charged nonrelativistic quantum mechanical particle and the (classical) electromagnetic field generated by the motion of the particle. We will discuss the well-posedness of this system.

Spherical waves in the expanding universe

Schedule: July 9 15:30-16:00 Room 739

Karen Yagdjian

University of Texas Rio Grande Valley, USA

Abstract:

In this talk, we present, in explicit form, the spherical waves in the FLRW universe with a scale factor generated by de-Sitter space. As an application of these explicitly written solutions of the Klein-Gordon and Dirac equations, we test the decay in time of the fields, which are generated by the pionic and hydrogen atoms. Details can be found in [1] K.Y.: Spherical solutions to the Klein-Gordon equation in the expanding universe. arXiv:2508.15812 [2] K.Y.: Propagation of Dirac spherical waves in the expanding universe. arXiv:2606.20483

Blow-up phenomena and lifespan estimates for nonlinear Klein-Gordon equations in FLRW spacetimes

Schedule: July 9 17:00-17:30 Room 739

Takuma Yoshizumi

The University of Osaka, Japan

Co-Author(s): Makoto Nakamura, Kimitoshi Tsutaya, Yuta Wakasugi

Abstract:

In this talk, we study the Cauchy problem for nonlinear Klein-Gordon equations with time dependent damping and mass. Power-type nonlinear terms including derivatives are considered, the equation involves time-dependent coefficients in the scale factor $a(t)$, damping term $b(t)$, and mass term $m(t)$. We establish the occurrence of finite-time blow-up for small initial data and derive upper bounds on the lifespan of blow-up solutions. As a concrete example, we focus on the equations in Friedmann-Lemaître-Robertson-Walker (FLRW) spacetimes, which describe the spatial expansion or contraction, and yield some important models of the universe. This talk is based on joint work with Makoto Nakamura, Kimitoshi Tsutaya, and Yuta Wakasugi.

Special Session 176 : Non-local Stochastic Evolutionary Systems: Theory and Applications

Organizer(s): Hao Tang , Kenneth Karlsen , Feng-Yu Wang

Introduction: This special session will explore non-local phenomena in stochastic evolutionary systems, with a particular emphasis on two important research directions: stochastic (partial) differential equations with non-locality in sample variables, and stochastic partial differential equations with non-locality in spatial variables. Discussions will span theoretical analysis, computational methods, and practical applications. The first direction focuses on systems such as McKean–Vlasov equations, which exhibit strong dependence on the probability distribution of solutions and provide a probabilistic framework for studying nonlinear Fokker–Planck equations and nonlinear Markov processes. Key topics include functional inequalities, asymptotic behavior of empirical measures under the Wasserstein-type metric, and systems driven by Lévy processes. The second direction concerns equations arising in applied contexts such as fluid dynamics, where non-local components—such as the pressure term—play an essential role. Discussions will emphasize non-local dissipative structures, transport mechanisms, and non-local random noise. Special attention will be devoted to mean-field stochastic fluid models that incorporate both distributional dependence and spatial non-locality. These hybrid models, which integrate dual non-local mechanisms, represent a rapidly advancing frontier in interdisciplinary research.

Global Solvability for Stochastic Superconducting Model

Schedule: July 8 16:30-17:00 Room 619

Nikolai V Chemetov

University of Sao Paulo, Brazil

Abstract:

In this work we study the stochastic hyperbolic superconductive model with an infinite dimensional multiplicative noise in a bounded domain. We establish the global-in-time existence result for weak martingale solutions to this stochastic model. The proof combines stochastic a priori estimates with compactness techniques based on our previous results. The dependence of the noise function makes the analysis of a priori estimates more difficult, giving rise to nonlinear terms induced by the martingale part of the equation.

A Dimension-Free Limiting Formula for Negative Sobolev Norms

Schedule: July 8 15:30-16:00 Room 619

Huaiqian Li

Tianjin University, Peoples Rep of China

Abstract:

We establish a dimension-free limiting formula for the norms of negative Sobolev spaces. These spaces play a fundamental role in fluid mechanics, and their norms are conveniently characterized via the heat kernel. Our main result captures a sharp nonlocal-to-local transition: as the fractional order tends to zero, negative Sobolev norm converges to a L^p norm. Our method is based on basic properties of the heat kernel and L^p -norm approximation techniques.

Eddy viscosity by Levy transport noise

Schedule: July 8 13:30-14:00 Room 619

Dejun Luo

Academy of Mathematics and Systems Science, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

We consider stochastic 2D Euler equations with L^2 -initial vorticity and driven by Lévy transport noise in the Marcus sense. Under a suitable scaling limit of the noises, we prove that the weak solutions converge weakly to the unique solution of the deterministic 2D Navier-Stokes equation. This shows that small scale jump noises generate eddy viscosity, extending the recent studies on Itô-Stratonovich diffusion limit to discontinuous setting. This is a joint work with Dr. Feifan Teng.

Convergence and Fluctuations of Singular Interacting Particle Systems with Non-Markov Noise

Schedule: July 8 9:30-10:00 Room 619

Avi Mayorcas

University of Bath, England

Abstract:

Systems of interacting particles are ubiquitous in physics, biology, chemistry, computer science and the social sciences. In many applications, the desired interaction potential is a highly singular function or distribution, making well-posedness, mean field convergence, and precise fluctuations challenging to obtain. A particularly relevant example are point vortex models of fluids where both singular interactions and non-Gaussian correlations are practically relevant. In this talk I will present recent results, obtained with L. Galeati and K. Le as well as ongoing work with J. Weinberger, on interacting particle systems driven by i.i.d. fractional Brownian motions (fBm), subject to irregular, possibly distributional, pairwise interactions. We show quantitative propagation of chaos and Gaussian fluctuations for these systems, where the singularity of the interaction may be chosen arbitrarily severe provided the noise fluctuates sufficiently fast (in a sense to be made formal). Our proofs rely on a combination of Sznitman's direct comparison argument with stochastic sewing techniques and U-statistics. Time permitting I will also present complementary results on multiplicative equations driven by fBm with singular volatility and ergodic theory for fBm driven coercive SDEs with singular drift.

Ergodicity of stochastic PDEs on unbounded domains

Schedule: July 8 17:30-18:00 Room 619

Vahagn Nersisyan

NYU Shanghai, Peoples Rep of China

Abstract:

In the last two decades, there has been significant progress in the understanding of ergodic properties of white-forced dissipative PDEs. The previous studies mostly focus on equations posed on bounded domains since they rely on different compactness properties and the discreteness of the spectrum of the Laplacian. In this talk, we will review recent results that make it possible to treat unbounded domains.

Intrinsic vs. Extrinsic Noise in Transient Dynamics: A Quasi-Stationary Approach

Schedule: July 8 14:30-15:00 Room 619

Weiwei Qi

Academy of Mathematics and Systems Science, CAS, Peoples Rep of China

Abstract:

Transient dynamics--long-lasting but ultimately finite-time behaviors--are ubiquitous in complex stochastic systems. Understanding their underlying mechanisms remains a fundamental challenge. In this talk, we investigate randomly perturbed processes arising in chemical reaction networks and population dynamics, where extinction is inevitable but preceded by long-lived persistence. Using quasi-stationary distributions (QSDs), we characterize these transient dynamics and analyze their asymptotics in the vanishing-noise regime. We show that intrinsic and extrinsic noise can induce fundamentally different transient dynamics, leading to distinct persistence and extinction patterns. We conclude with a discussion of broader implications and open problems.

On the stability of stochastic processes with regime-switching

Schedule: July 8 8:30-9:00 Room 619

Jinghai Shao

Tianjin University, Peoples Rep of China

Abstract:

The stochastic processes with regime-switching are extensively used for modeling the realistic systems in control engineering, which experience abrupt changes in structure or parameters. This talk concerns the long time behavior of regime-switching systems, focusing on the impact of infinitely countable switching states and the delayed observations.

Stochastic Euler Equations with Pseudo-differential Noise

Schedule: July 8 17:00-17:30 Room 619

Hao Tang

Tianjin University, Peoples Rep of China

Abstract:

We study stochastic Euler equations in both compressible and incompressible regimes, on the whole space and on the torus, driven by genuinely mixed multiplicative noise comprising a continuous component (in both the Stratonovich and It^o senses) and a discontinuous component (in the Marcus sense). The Stratonovich/Marcus noise amplitudes are (nonlocal) pseudo-differential operators that include, as special cases, the classical transport operator. Within this setting, we develop a local-in-time theory of classical solutions for both regimes, establishing existence, uniqueness, and a blow-up criterion. The inclusion of discontinuous pseudo-differential Marcus noise is novel and necessitates additional analytical techniques to control the interaction between jumps and nonlocal operators. In the compressible barotropic case, we consider a broad class of physically relevant pressure laws extending far beyond the polytropic γ -law. This class includes piecewise-defined γ -laws, (piecewise-defined) Chaplygin-type laws, the pressure of white dwarf stars, and other astrophysically relevant regimes. These pressure laws have not been analyzed in the literature on stochastic compressible fluids, even under purely It^o-type forcing. For the incompressible damped equations, we specify a hierarchy of damping-noise conditions of increasing strength that yield global-in-time existence, uniform-in-time bounds, and decay estimates, respectively. To analyze invariant measures, we formulate an abstract singular stochastic evolution system that captures Euler-specific features, notably the mismatch between the topology in which solutions are constructed and the topology in which the Feller property holds. We extend the Krylov--Bogoliubov argument to accommodate this mismatch, establishing existence and uniqueness of invariant measures for the stochastic incompressible damped Euler equations. This provides the first positive answer to a strengthened version of Shirikyan's problem.

Statistically stationary solutions to the stochastic compressible Euler equations with linear damping

Schedule: July 8 14:00-14:30 Room 619

Krutika Tawri

University of Washington, USA

Co-Author(s): Jeffrey Kuan, Konstantina Trivisa

Abstract:

In this talk, we will discuss the existence of statistically stationary solutions to the linearly damped stochastic compressible Euler equations in one spatial dimension. The system of isentropic compressible Euler equations, describing the evolution of the density and momentum of a compressible fluid, is driven by a multiplicative noise. Additionally, the momentum equation consists of a small linear damping term. The power law for the pressure is given in terms of the density. We show the existence of statistically stationary weak martingale entropy solutions to these equations for any adiabatic constant and any damping coefficient, namely stochastic solutions for which the law of the solution is constant in time. To establish this result, we consider an approximate system for which we show the existence of an invariant measure, and then pass to the limit in the approximation parameters in order to obtain a limiting statistically stationary solution. We develop new techniques for obtaining uniform-in-time estimates for entropies of all orders, and study invariant regions of the approximate system. Such a result is a significant step in understanding the long-time statistics of stochastically perturbed compressible inviscid fluids.

Quantitative Convergence and Gaussian Fluctuations for Sequential Interacting Diffusions via Incremental Relative Entropy

Schedule: July 8 9:00-9:30 Room 619

Zhenfu Wang

Peking University, Peoples Rep of China

Co-Author(s): Xianliang Zhao

Abstract:

We study a sequential system of interacting diffusions in which particle i interacts only with its predecessors through the empirical measure μ_t^{i-1} , yielding a directed, non-exchangeable mean-field approximation of a McKean--Vlasov diffusion. Under bounded coefficients and a non-degenerate constant diffusion, we prove the sharp decay of incremental path-space relative entropies,

$$R_i(T) := H\left(P_{[0,T]}^{1:i} \mid P_{[0,T]}^{1:i-1} \otimes \bar{P}_{[0,T]}\right) \lesssim \frac{1}{i-1}, \quad i \geq 2,$$

where $P_{[0,T]}^{1:i}$ is the law of the first i particle paths and $\bar{P}_{[0,T]}$ the McKean--Vlasov path law. Summing the increments yields the global estimate

$$H\left(P_{[0,T]}^{1:N} \mid \bar{P}_{[0,T]}^{\otimes N}\right) \lesssim \log N,$$

together with quantitative decoupling bounds for tail blocks. As a consequence, the empirical measure converges to the McKean--Vlasov equation in negative Sobolev topologies at the canonical $N^{-1/2}$ scale. We also establish a Gaussian fluctuation limit for the fluctuation measure, where the sequential architecture produces an explicit feedback correction in the limiting linear SPDE. Our proofs rely on a Girsanov representation, a martingale-difference replacement of predecessor empirical measures by average conditional measures, and an upper-envelope argument.

Mean Field Control with Poissonian Common Noise: A Pathwise Compactification Approach

Schedule: July 8 15:00-15:30 Room 619

Xiaoli Wei

Harbin Institute of Technology, Peoples Rep of China

Abstract:

This paper contributes to the compactification approach to study mean-field control problems with Poissonian common noise. To overcome the lack of compactness and continuity issues caused by common noise, we exploit the point process representation of the Poisson random measure with finite intensity and propose a pathwise formulation in a two step procedure by freezing a sample path of the common noise. In the first step, we establish the existence of the optimal relaxed control in the pathwise formulation as if common noise is absent, but with finite deterministic jumping times. The second step plays the key role in our approach, which is to aggregate the optimal solutions in the pathwise formulation over all sample paths of common noise and show that it yields an optimal solution in the original model. To this end, with the help of concatenation techniques, we first develop a pathwise superposition principle in the model with deterministic jumping times, drawing a relationship between the pathwise relaxed control problem and the pathwise measure-valued control problem. As a result, we can further bridge the equivalence among different problem formulations and verify that the constructed solution under aggregation is indeed optimal in the original problem.

Special Session 177 : Innovations in Data Assimilation: Theory, Algorithms, and Application

Organizer(s): Adam Larios , Jared Whitehead

Introduction: This mini-symposium brings together researchers and practitioners to explore the broad landscape of data assimilation, bridging theoretical foundations and practical applications. Theoretical topics include nudging-based approaches, continuous data assimilation, and their link to PDEs, control theory, and error analysis. On the applied side, the symposium will highlight Bayesian and filtering methods such as the ensemble Kalman filter, particle filter, and continuous-in-time formulations like nudging and the ensemble Kalman-Bucy filter, with applications in climate, atmospheric, and engineering systems. A central aim is to foster connections between data assimilation and related areas, such as machine learning, stochastic modeling, parameter estimation, and optimal control, to promote interdisciplinary collaboration and inspire new research directions. The event will also provide an engaging platform for early-career researchers to exchange ideas and gain exposure to modern methods for complex dynamical systems.

DASSH -- Diffusion-Accelerated Smoothing using Score-based Heuristics

Schedule: July 9 17:00-17:30 Room 442

Marios Andreou

University of Wisconsin-Madison, USA

Co-Author(s): Nan Chen, Daniele Venturi

Abstract:

Bayesian data assimilation (BDA) combines partial observations with physics-informed dynamical models to estimate latent system states. Filter-based BDA uses past and present data, enabling online forecasting, while smoothing additionally incorporates future observations for hindcasting and reanalysis. However, smoothing typically requires storing the full filter history and inverting filter statistics (e.g., covariance matrix), which is prohibitive in high-dimensional settings. In this work, we introduce a framework that leverages the score-based structure of a backward diffusion flow, whose marginal law at any time matches the smoother posterior distribution. This backward-in-time stochastic differential equation generates samples of the unobserved states consistent with the smoother distribution. For a broad class of nonlinear systems this equation admits a closed-form analytical expression, while for more general systems a Gaussian statistical approximation can be obtained via an ensemble Kalman-Bucy smoother. These formulations enable training a neural network via score matching, alleviating the storage and computational costs of traditional smoother-based BDA. The trained score network can also generalize to unseen states, potentially enabling forward-in-time extrapolation. The developed methodology is demonstrated on complex high-dimensional systems with dense covariance structures arising from multiplicative and cross-correlated noise and strongly nonlinear dynamics, achieving accurate smoothing while reducing memory and computational costs.

Estimating High-Dimensional Covariance Matrices with Hierarchical Rank Structure

Schedule: July 9 Room 442

Robin Armstrong

Cornell University, USA

Abstract:

Many algorithms in data assimilation and model order reduction rely on sample-based estimates for a covariance matrix associated with the trajectory of a high-dimensional dynamical system. Due to computational constraints, the number of available samples is often far less than the dimension of the underlying state space, necessitating the use of regularization techniques such as spatial localization. This talk will examine systems whose behavior is governed by a range of widely separated correlation lengthscales, giving rise to a covariance structure that is not spatially localized. We will show how to estimate these covariance matrices from a small number of samples by exploiting the rank structure of submatrices representing cross-covariances between well-separated domains of space. Our techniques produce covariance estimators that are hierarchically rank-structured; as a result, they have a small memory footprint and support highly efficient matrix computations for downstream tasks in data assimilation and model reduction. Using both theoretical error bounds and numerical experiments with a variety of dynamical systems, we will demonstrate that our estimators can accurately recover the underlying covariance matrix from a very small number of samples.

Learning probabilistic filters for data assimilation

Schedule: July 10 8:30-9:00 Room 442

Eviatar Bach

University of Reading, England

Co-Author(s): Ricardo Baptista, Jochen Broecker, Edoardo Calvello, Bohan Chen, Andrew Stuart

Abstract:

Filtering, the problem of estimating the probability distribution of a system's states given partial and noisy observations, is generally intractable for high-dimensional, nonlinear systems. The ensemble Kalman filter (EnKF) approximates the filtering distribution with an ensemble of interacting particles, employing a Gaussian ansatz for the joint distribution of the state and observation at each observation time. The EnKF is robust, but the Gaussian ansatz limits accuracy. We address this shortcoming by using machine learning to map the forecast distribution and observation to the filtering distribution. We propose cost functions that are minimized uniquely at the true filtering distribution. By time-averaging over long trajectories in ergodic dynamical systems, the map can be learned and subsequently used for future filtering; this is a form of amortized Bayesian inference. We focus on learning ensemble-based filters within a mean field framework. We demonstrate the approach using a set transformer neural architecture, which is invariant to ensemble permutations. The learned filtering algorithms outperform state-of-the-art methods for filtering chaotic systems. They also perform well in challenging highly non-Gaussian and multimodal problems where the EnKF fails. Once learned at a given ensemble size, the learned map can be applied to other ensemble sizes with minimal fine-tuning.

Challenges in Data Assimilation and Ideas for Addressing Them

Schedule: July 9 18:00-18:30 Room 442

Jana de Wiljes

Ilmenau University of Technology, Germany

Abstract:

Data assimilation in applications such as numerical weather prediction faces inherent difficulties due to the nonlinear and often chaotic dynamics of the underlying systems. The high dimensionality of these models, coupled with their prohibitive computational cost, forces practitioners to rely on crude approximations. Despite these limitations, data assimilation methods have demonstrated remarkable skill in tracking signals, while rigorous mathematical analysis is still catching up to rigorously proof corresponding accuracy results. A central challenge going forward is to develop more accurate representations of uncertainty both for reliable estimation and for solving optimal design problems related to observation strategies and filtering. In this talk, we will explore these challenges and present state-of-the-art approaches that aim to bridge the gap between practice and theory.

Data Assimilation in Turbulent Flows: Model Mismatch and Incomplete Dissipation

Schedule: July 10 8:00-8:30 Room 442

Adam Larios

University of Nebraska-Lincoln, USA

Co-Author(s): Trenton Franz, Amanda Rowley, Nick White

Abstract:

A major difficulty in accurately simulating turbulent flows is the problem of determining the initial state of the flow. For example, weather prediction models typically require the present state of the weather as input. However, the state of the weather is only measured at certain points, such as at the locations of weather stations or weather satellites. Data assimilation eliminates the need for complete knowledge of the initial state. It incorporates incoming data into the equations, driving the simulation to the correct solution. The objective of this talk is to discuss innovative computational and mathematical methods to test, improve, and extend a promising new class of algorithms for data assimilation in turbulent flows and related systems. We will look at how these techniques can be adapted to settings involving model mismatch or with incomplete dissipation.

Error analysis of proper orthogonal decomposition data assimilation schemes for the Navier-Stokes equations with grad-div stabilization

Schedule: July 9 17:30-18:00 Room 442

Julia Novo

Universidad Autonoma de Madrid, Spain

Co-Author(s): Bosco Garcia-Archilla, Samuele Rubino

Abstract:

The error analysis of a proper orthogonal decomposition (POD) data assimilation (DA) scheme for the Navier-Stokes equations is carried out. A grad-div stabilization term is added to the formulation of the POD method. Error bounds with constants independent on inverse powers of the viscosity parameter are derived for the POD algorithm. No upper bounds in the nudging parameter of the data assimilation method are required. Numerical experiments show that, for large values of the nudging parameter, the proposed method rapidly converges to the real solution, and greatly improves the overall accuracy of standard POD schemes up to low viscosities over predictive time intervals.

Continuous Data Assimilation with Learned Surrogate Dynamics

Schedule: July 10 9:00-9:30 Room 442

Daniel Sanz-Alonso

University of Chicago, USA

Abstract:

Continuous data assimilation concerns estimating the state of a dynamical system from partial measurements. In many applications, the state dynamics are unknown or too expensive to simulate at the desired resolution, leading to model error. Motivated by this challenge and the increasing use of machine learning surrogates in data assimilation, this talk presents a unified analysis of nudging algorithms that employ learned surrogate models of the dynamics. We first establish general conditions on the dynamics and measurements under which nudging with the true dynamics model achieves accurate tracking, both in the noise-free setting and under noisy measurements. We then show that nudging algorithms that employ surrogate models retain exponential convergence up to an explicit error floor that quantifies the effects of surrogate approximation error and measurement noise. Finally, we analyze surrogate models constructed by learning either the vector field governing the dynamics or the system's solution map over a short time step. Our results quantify the amount of training data required for accurate nudging with these learned surrogate models. Numerical experiments illustrate and support the theory.

Analysis of Data-Driven Smoothing and Forecasting

Schedule: July 9 18:30-19:00 Room 442

Andrew Stuart

Caltech, USA

Co-Author(s): Edoardo Calvello, Elizabeth Carlson, Nikola Kovachki, Michael N. Manta, and Andrew M. Stuart

Abstract:

Machine learning has opened new frontiers in purely data-driven algorithms for data assimilation, and for forecasting of dynamical systems, the resulting methods are showing some promise. However, in contrast to model-driven algorithms, analysis of these data-driven methods is poorly developed. In this paper we address this issue, developing a theory to underpin data-driven methods to solve smoothing and forecasting problems. The theoretical framework relies on two key components (i) establishing the existence of the mapping to be learned (ii) the properties of the machine learning architecture used to approximate this mapping. By studying these two components in conjunction, we establish the first universal approximation theorem for purely data-driven algorithms for data assimilation and forecasting of dynamical systems. We work in continuous time setting, hence deploying neural operator architectures. The theoretical results are illustrated with experiments studying the Lorenz 63, Lorenz 96 and Kuramoto-Sivashinsky dynamical systems.

Spectral Viscosity with Continuous Data Assimilation: Model Mismatch

Schedule: July 10 9:30-10:00 Room 442

Nicholas White

University of Nebraska-Lincoln, USA

Co-Author(s): Adam Larios

Abstract:

Continuous Data Assimilation aims to reconstruct the solution of a dissipative system given partial observations of large-scale data. Spectral viscosity, introduced by Tadmor (1989) applies dissipation only on small scales in order to resolve numerical simulations. In this work, we discuss the use of the Continuous Data Assimilation algorithm on the 2D Navier-Stokes Equations with only spectral viscosity. We also discuss the consequences of mismatch in dissipation strength between the observed and simulated solutions.

System Identification via Optimization in Data Assimilation

Schedule: July 9 16:30-17:00 Room 442

Jared P Whitehead

Brigham Young University, USA

Abstract:

Classical system identification techniques suffer from the need to have full observations of the system in question. If instead, we couple the observations with data assimilation, and then minimize the observed error over the unknown coefficients/parameters of the proposed model, then we are able to reconstruct unknown systems from partial observations. Standard optimization routines require gradients of the system which can be addressed via adjoint methods or, as we demonstrate, when the unknown parameters lie in the observed space of the proposed model, we can utilize an asymptotic representation of the sensitivities, yielding an efficient method for parameter and hence system identification in both the linear and nonlinear setting.

Abstracts for Special Sessions

Special Session 178 : Nonlinear Evolution Equations and Related Topics

Organizer(s): Goro Akagi , Michinori Ishiwata , Mitsuharu Otani

Introduction: This session will focus on recent developments in the theory of Nonlinear Evolution Equations and related topics. It will cover the theory of abstract evolution equations in Banach spaces, as well as the study of various types of nonlinear partial differential equations, including the existence, regularity, and asymptotic behavior of solutions.

On the nonsmooth analysis of doubly nonlinear evolution equations of second order

Schedule: July 7 8:30-9:00 Room 640

Aras Bacho

California Institute of Technology, USA

Abstract:

Existence of strong solutions of an abstract Cauchy problem for a class of doubly nonlinear evolution inclusion of second order is established via a semi-implicit time discretization method. The principal parts of the operators acting on u and $u^{\prime}$ are multi-valued subdifferential operators and are discretized implicitly. A non-variational and non-monotone perturbation acting nonlinearly on u and $u^{\prime}$ is allowed and discretized explicitly in time. The convergence of a variational approximation scheme is established using methods from convex analysis. In addition, it is proven that the solution satisfies an energy-dissipation equality. Applications of the abstract theory to various examples, e.g., a model in visco-elastic-plasticity, are provided.

Global existence and boundedness in a quasilinear attraction-repulsion chemotaxis system

Schedule: July 7 18:30-19:00 Room 640

Yutaro Chiyo

Tokyo University of Science, Japan

Co-Author(s): Kazuki Hasegawa, Tomomi Yokota

Abstract:

This talk deals with a quasilinear attraction-repulsion chemotaxis system. The purpose of this talk is to show global existence and boundedness of classical solutions by applying energy methods.

Cauchy Problem for a Cubic Novikov Equation

Schedule: July 7 16:30-17:00 Room 640

Nilay Duruk Mutlubas

Sabanci University, Turkey

Abstract:

The partial differential equation with cubic nonlinearity proposed by Novikov [1] will be discussed in this talk:

$$\begin{equation*} (1-\partial_x^2)u_t = (1+\partial_x)(u^2u_{xx} + uu_x^2 - 2u^2u_x). \end{equation*}$$
 Initial value problems corresponding to the equation either on the line or on the circle will be presented. The recent results obtained both for local existence and finite time blow-up of solutions will be provided referring to the ideas recently proved in [2,3] for the quadratic nonlinear equation as a member of the integrable family of equations proposed by Novikov. [1] V. Novikov, Generalizations of the Camassa-Holm equation, J. Phys. A: Math. Theor., vol. 42, paper 342002, (2009). [2] N. Duruk Mutlubas and I. L. Freire, Existence and uniqueness of periodic pseudospherical surfaces emanating from Cauchy problems, Proc. R. Soc. A., vol. 480, paper 20230670, (2024). [3] N. Duruk Mutlubas and I. L. Freire, Global and blow-up solutions for a non-local integrable equation with applications to geometry, <https://doi.org/10.48550/arXiv.2505.12232>, (2025).

Asymptotic behavior of nonlinear Robin energies with convex boundary nonlinearities

Schedule: July 7 14:30-15:00 Room 640

Kosuke Kita

Hokkaido university, Japan

Abstract:

In this talk, we consider boundary energies generated by convex functions. Motivated by recent work by Buttazzo--Ognibene (arXiv:2506.06914) on nonlinear Robin energies with power-type boundary nonlinearities, we study asymptotics for nonlinear Robin energies with more general boundary nonlinearities. While the power case already reveals the Dirichlet and Neumann limiting behaviors, it is natural to ask whether the same mechanism remains valid beyond polynomial growth. Our aim is not only to enlarge the class of admissible nonlinearities, but also to replace arguments tied to explicit power computations with a unified variational framework based on convex duality and Moreau--Yosida regularization. This approach identifies the leading-order asymptotic term through the convex conjugate of the boundary energy and yields quantitative control of the remainder under suitable assumptions. In this way, we recover the classical power-type situation as a special case, while covering genuinely non-power boundary responses that lie outside the scope of explicit model-dependent calculations. These results provide a variational perspective on how Dirichlet- and Neumann-type limits emerge from nonlinear boundary penalization.

Non-linear evolution equations arising from mathematical models in biology with proliferation and re-establishment

Schedule: July 7 15:30-16:00 Room 640

Akisato Kubo

Fujita Health University, Japan

Abstract:

In this talk we investigate the global existence in time and asymptotic profile of the solution of a nonlinear evolution equation: $w_t = D\Delta w + \nabla \cdot (\alpha(w)e^{-l(t)}\chi[w]) + \mu(1-w)w + \beta(1-w)$, arising from non-local mathematical models in biology with proliferation and re-establishment, for $l(t) = a + dt$, $a, d > 0$, where D, μ are positive constants, $\alpha(\cdot)$ and $\beta(\cdot)$ are polynomial functions with respect to $\cdot$, Ω is a bounded domain in $\mathbb{R}^n$ with smooth boundary $\partial\Omega$ and ν is the outer unit normal vector on $\partial\Omega$, $\chi[w]$ is a non-local term. By making use of the related singular integral operator, we consider the initial and zero-Neumann boundary value problem and derive estimates required for our desired result. We will apply our result to the original non-local mathematical model (by Gerisch and Chaplain), which reflects the mathematical understanding of the biological processes described cell migration in vivo.

Weighted Inertia-Dissipation-Energy approach to doubly nonlinear wave equations

Schedule: July 7 9:30-10:00 Room 640

Alice Marvaggio

University of Bonn, Germany

Co-Author(s): Goro Akagi, Verena Boegelein, and Ulisse Stefanelli

Abstract:

We discuss a variational approach to doubly nonlinear wave equations of the form $\rho u_{tt} + g(u_t) - \Delta u + f(u) = 0$. This approach hinges on the minimization of a parameter-dependent family of uniformly convex functionals over entire trajectories, namely the so-called Weighted Inertia-Dissipation-Energy (WIDE) functionals. We prove that the WIDE functionals admit minimizers and that the corresponding Euler-Lagrange system is solvable in the strong sense. Moreover, we check that the parameter-dependent minimizers converge, up to subsequences, to a solution of the target doubly nonlinear wave equation as the parameter goes to 0. The analysis relies on specific estimates on the WIDE minimizers, on the decomposition of the subdifferential of the WIDE functional, and on the identification of the nonlinearities in the limit.

Global solvability of the Q-tensor model for nematic liquid crystals

Schedule: July 7 14:00-14:30 Room 640

Miho Murata

Shizuoka University, Japan

Co-Author(s): Daniele Barbera, Yoshihiro Shibata

Abstract:

The molecules of nematic liquid crystal flow as in a liquid phase; however, they have an orientation order. The orientation order is described by the symmetric, traceless matrix Q . Beris and Edwards proposed a Q-tensor model, the coupled system of the Navier-Stokes equations and a parabolic-type equation describing the evolution of the order parameter Q , to represent nematic liquid crystal flows. The aim of this talk is to prove the unique existence of the global-in-time solution for small initial data in the maximal regularity class for the Q-tensor model in the half-space $\mathbb{R}_+^N$, $N \geq 2$. In this talk, we especially discuss the weighted estimates of solutions for the linearized problem to control the higher-order terms of the solutions. This talk is based on joint work with Prof. Yoshihiro Shibata (Waseda University) and Dr. Daniele Barbera (Politecnico di Torino).

Two-material optimal design problem for the heat equation

Schedule: July 7 17:30-18:00 Room 640

Tomoyuki Oka

Department of Intelligent Mechanical Engineering/Fukuoka Institute of Technology, Japan

Co-Author(s): Kei Matsushima

Abstract:

In this talk, we consider a two-material optimal design problem for the time-averaged duality pairing between a heat source and the weak solution of an initial-boundary value problem for the heat equation with a two-material diffusion coefficient, under a volume constraint. From the viewpoint of optimality, we focus on the long-time behavior of solutions to the relaxed problem.

A panoramic view of exponential attractors

Schedule: July 7 13:30-14:00 Room 640

Stefanie Sonner

Radboud University, Netherlands

Co-Author(s): Radosław Czaja

Abstract:

We provide a unifying framework for the construction of exponential attractors for infinite dimensional dynamical systems that allows us to generalize, improve and compare existing methods that are commonly used to construct exponential attractors. For autonomous deterministic systems we formulate necessary and sufficient conditions for the existence of discrete exponential attractors in terms of a covering condition for iterates of the absorbing set under the time evolution of the semigroup. The parameters in the covering condition determine the estimate for the fractal dimension of the exponential attractor and the exponential rate of attraction. We then verify the covering condition for existing approaches to construct exponential attractors where the most general setting concerns quasi-stable semigroups in complete metric spaces. Generalizing previous notions and methods used in the literature on exponential attractors then allows us to compare widely used approaches. To conclude, we mention generalizations of the constructions for non-autonomous and random dynamical systems.

Parametric nonlinear nonhomogeneous singular problems with an indefinite perturbation

Schedule: July 7 15:00-15:30 Room 640

VASILE STAICU

University of Aveiro, Portugal

Co-Author(s): Sergiu Aizicovici, N. S. Papageorgiou and Vasile Staicu

Abstract:

{ We consider a singular Dirichlet problem driven by a nonlinear nonhomogeneous differential operator and with a reaction involving the competing effects of a parametric singular term and of an indefinite superlinear Caratheodory perturbation. Using variational tools together with truncation and comparison techniques, we prove an existence and multiplicity result which is global in the parameter $\lambda > 0$ (a bifurcation-type theorem). }

Long-term behavior in a model for tuberculosis granuloma formation

Schedule: July 7 18:00-18:30 Room 640

Yuya Tanaka

Department of Mathematical Sciences, Kwansei Gakuin University, Japan

Co-Author(s): Masaaki Mizukami

Abstract:

This talk deals with a model for tuberculosis granuloma formation. This model was proposed by Feng (J. Nonlinear Complex Data Sci.; 2024; 25; no. 1, 19-35), and moreover, global existence of classical/weak solutions was established in 2-3-dimensional settings by Fuest, Lankeit and Mizukami (Nonlinear Anal. Real World Appl.; 2025; 85; Paper No. 104369, 14 pp). However, the long-term behavior of these solutions has remained open. The purpose of this talk is to show asymptotic stability of constant equilibria and grow-up of solutions. This is a joint work with Masaaki Mizukami (Kyoto University of Education).

A doubly nonlinear parabolic equation with nonlinear perturbation under relaxed growth and exponent conditions

Schedule: July 7 8:00-8:30 Room 640

Shun Uchida

Oita University, Japan

Co-Author(s): Shun Uchida

Abstract:

In this talk, we consider the initial boundary value problem for a doubly nonlinear parabolic equation with nonlinear perturbation, subject to homogeneous Dirichlet boundary conditions. Our main goal is to relax the growth conditions on the nonlinear term and to reduce the constraints on the exponent range, allowing the results to cover both singular and degenerate cases. The proof relies on an L^∞ -estimate for a time-discrete problem, obtained in earlier work, combined with the L^∞ -energy method.

Asymptotic stability of the composite wave for the generalized Burgers equation

Schedule: July 7 Room 640

Yoshihiro Ueda

Kobe University, Japan

Abstract:

We consider the stability of the composite wave for the generalized Burgers equation. Especially, we focus on the case that the flux function is non-convex. Then the corresponding Riemann problem admits a Riemann solution which consists of an Oleinik shock and a rarefaction wave. In this situation, we will show the asymptotic stability of the composite wave of the viscous Oleinik shock and the rarefaction wave. This is a joint research with Masaya Kageura from Kobe University.

A variational approach to optimal control of gradient flows

Schedule: July 7 9:00-9:30 Room 640

Riccardo Voso

UTIA, Czech Academy of Sciences, Czech Rep

Co-Author(s): Ulisse Stefanelli, Takeshi Fukao

Abstract:

We consider a general optimal control problem in the setting of gradient flows. Two approximations of the problem are presented, both relying on the variational reformulation of gradient-flow dynamics via the Weighted-Energy-Dissipation variational approach. This consists in the minimization of global-in-time functionals over trajectories, combined with a limit passage. We show that the original nonpenalized problem and the two successive approximations admits solutions. Moreover, resorting to a Γ -convergence analysis we show that penalised optimal controls converge to nonpenalized one as the approximation is removed.

Ground state solution for the nonlinear Schrödinger-Poisson system and its link with the Gagliardo-Nirenberg-Coulomb inequality

Schedule: July 7 17:00-17:30 Room 640

Tatsuya Watanabe

Kyoto Sangyo University, Japan

Co-Author(s): Yu Su

Abstract:

In this talk, we consider the nonlinear Schrödinger-Poisson system. The aim of this talk is to present a complete characterization of the energy ground state solution for a critical strength of the interaction. Firstly, we prove the existence of an optimizer of the Gagliardo-Nirenberg-Coulomb inequality. Secondly, we give a full correspondence between an optimizer, an energy ground state solution and an action ground state solution. Finally, we obtain an explicit formula of the critical strength by using the optimizer and the best constant of the Gagliardo-Nirenberg-Coulomb inequality.

Special Session 180 : Individual and Collective Cells Dynamics in Medicine and Biology

Organizer(s): Dumitru Trucu , Raluca Eftimie , Yangjin Kim

Introduction: Despite the scientific progresses in understanding both individual and collective cell dynamics via in vivo and in vitro wet-lab experimental work, the main mechanisms standing behind the complex dynamics of key processes in the human body (ranging from cancer invasion to immune response, to wound healing and tissue development) is far from being elucidated. However, mathematical modelling, accompanied by analysis, and computational implementations of key aspects of these processes enabled significant steps forward in both pathological and normal situations. Indeed, mathematical modelling contributes directly not only to validating experimental work but also to formulating and advancing new hypotheses, both regarding the process dynamics and suggesting treatment strategies (in pathological situations) that could be subsequently tested experimentally or clinically. This Special Session aims to bring together brilliant young scientists and world experts in mathematical modelling addressing various aspects in individual and collective cell dynamics through innovative approaches that range from single scale agent based as well as continuum local and nonlocal approaches to complex multiscale advancements. This aims to incentivise cross-fertilisation discussions among the participants, hoping that these will generate innovative modelling and computational advancements that will ultimately enable avenues for deeper understanding of these key processes in living systems.

Optimal Control of Cell Plasticity in GBM Cells via Levy-Driven Microscopic Dynamics

Schedule: July 8 13:30-14:00 Room 433

Sandesh Athni Hiremath

Rhinelandpfalz Technical University, Germany

Abstract:

Glioblastoma (GBM) is a highly aggressive brain tumor characterized by extensive cellular heterogeneity and plasticity, which underlie its resistance to therapy and poor prognosis. Understanding and predicting the dynamic trajectories of GBM cell states is crucial for designing effective interventions. We propose a low-dimensional microscopic model driven by Levy noise that aims to capture the dynamics of gene regulation and transitions between phenotypic cell states. By formulating a stochastic optimal-control problem, we aim to find a suitable profile for the cell transcription factors that can drive cell-state transitions towards a particular desired state. Following this, we establish a macroscopic model for the system and propose a framework for integrating high-throughput single-cell data, thus offering a powerful tool for understanding GBM dynamics and guiding therapeutic development.

Beyond Differential Expression: A Robust ML Framework for Keloid Biomarker Discovery

Schedule: July 8 9:00-9:30 Room 433

Ali R Daher

Marie and Louis Pasteur University, France

Co-Author(s): Ali Daher, Fareeha Afzal, Raluca Eftimie

Abstract:

Keloids are fibroproliferative skin disorders that arise following injury and extend beyond the original wound margins. Despite their clinical burden, their pathogenesis remains poorly understood, and current treatments are associated with high recurrence rates. Identifying biomarkers that uniquely distinguish keloids from other skin/scar types may provide insight into their underlying etiology and guide targeted therapeutic strategies. Previous studies have investigated candidate biomarkers; however, they are often limited by small sample sizes, restricted comparisons (e.g., keloid vs. hypertrophic scars), cross-platform inconsistencies, and reliance on conventional metrics such as fold-change, which may not capture the keloid uniquely distinguishing features. We present a rigorous, multi-layered machine learning framework to identify robust biomarkers that distinguish keloid from non-keloid samples. We curated and harmonized transcriptomic datasets (81 samples, 13 studies) across four tissue types: normal skin, normal scar, hypertrophic scar, and keloids, accounting for batch and technical variability. Using multiple classification algorithms with study-aware cross-validation, feature selection, stability analysis, and bootstrapping, we identified a minimal set of highly consistent genes with strong discriminatory power. Gene enrichment analysis of the five upregulated and three downregulated genes highlights increased lipid metabolism and decreased extracellular matrix organization as the dominant pathways affected, offering potential avenues for targeted treatment.

Computational investigation into the formation of nodules and cords during the evolution of the fibroproliferative Dupuytren Disorder

Schedule: July 8 17:30-18:00 Room 433

Raluca EFTIMIE

University Marie and Louis Pasteur, France

Co-Author(s): Georgiana Eftimie

Abstract:

Dupuytren Disorder (DD) is a fibro-proliferative disorder characterised by fibrosis of palmar and digital fascia that leads to finger flexion deformities. It starts with a nodule in the palm, that can evolve into fibrous cords. Here, we present a simple mathematical model that can reproduce the main tissue-level patterns of DD: nodules, nodular cords and non-nodular cords. We investigate the parameters that have the most impact on cord contraction, and confirm that the fibroblast-to-myofibroblast transition is one of these parameters. Also, the amount of the injury signal required to trigger this transition seem to be important in Dupuytren contraction, pointing towards a potential link to individual genetics.

Data-driven modeling for Alzheimer`s disease

Schedule: July 8 9:30-10:00 Room 433

Wenrui Hao

Penn State University, USA

Abstract:

Alzheimer's disease (AD) is highly heterogeneous, with patients showing different biomarker trajectories, progression rates, and treatment responses. Traditional models offer insight but miss individual variability. We integrate machine learning with mechanistic mathematical modeling to build patient digital twins that simulate disease progression and test personalized therapies. This framework deepens understanding of the biomarker cascade and supports precision medicine, with potential to reduce clinical trial cost and accelerate therapeutic development.

Behavioral Feedback and Perceived Prevalence: Reconciling Epidemic Dynamics in a Classic Boarding School Outbreak

Schedule: July 8 15:00-15:30 Room 433

Harsh Jain

University of Minnesota Duluth, USA

Abstract:

Mathematical models of infectious disease transmission increasingly support public health decision-making, yet observed epidemic dynamics reflect not only pathogen biology but also adaptive human behavior. Behavioral responses to perceived risk can alter contact patterns and transmission. When such feedbacks are ignored or absorbed into constant parameters, models may reproduce epidemic trajectories while implying unrealistic outbreak sizes. In this talk, we revisit the well-known 1978 influenza outbreak in a British boys boarding school. Standard SIR models fitted to the infection time series typically fail to explain the large fraction of students who remained uninfected. We show that this discrepancy reflects a structural limitation of constant-transmission models rather than a parameter estimation issue. We then infer a time-varying transmission rate and introduce perceived prevalence, a short-term memory of recent infections that approximates how severe the outbreak appears to the population. Incorporating this behavioral driver allows a minimal SIR model to match both the infection time course and the final outbreak size. We then translate these inferred dynamics into an agent-based model to examine whether the behavioral response reflects reduced contact rates or changes in per-contact transmission probability, while allowing heterogeneity in susceptibility through innate immunity among the students.

Modeling Collective Pattern Formation in Biological Reaction-Diffusion Systems Using Moving Mesh Methods

Schedule: July 7 18:30-19:00 Room 433

Darae Jeong

Kangwon National University, Korea

Abstract:

Collective pattern formation arises in many biological systems, including cell aggregation, tissue organization, animal skin patterns, and interacting populations. Reaction-diffusion models provide an effective framework for describing the emergence and evolution of such spatial structures, but numerical simulation becomes challenging when solutions develop localized patterns, sharp gradients, and multiscale features. In this talk, I present moving mesh methods as an efficient computational approach for biological reaction-diffusion systems. The main idea is to adaptively redistribute mesh points according to the evolving solution profile, so that computational effort is concentrated near regions with significant spatial variation while unnecessary resolution is avoided elsewhere. I will discuss the basic idea and implementation of the moving mesh framework combined with finite difference discretizations, and illustrate its performance through examples exhibiting spike-type patterns, transition layers, and self-organized structures. These results show that moving mesh methods provide a practical and accurate tool for analyzing complex pattern formation phenomena in mathematical biology.

Mathematical modeling of glioblastoma dynamics and development of anti-cancer therapy in brain: Trojan neutrophils

Schedule: July 7 16:30-17:00 Room 433

Yangjin Kim

Konkuk University/Brown University, Korea

Co-Author(s): Haneol Cho, Junho Lee, Sean Lawler

Abstract:

Glioblastoma multiforme (GBM) is the most aggressive form of brain cancer with the very poor survival and high recurrence rate. Tumor-associated neutrophils (TANs) play a pivotal role in regulation of the tumor microenvironment. In this study, we developed a new multi-scale model of the critical GBM-TAN interaction in the heterogeneous brain tissue. The model reveals that the dual and complex role of TANs (either anti-tumorigenic N1 and the pro-tumorigenic N2 type) regulates the phenotypic trajectory of the evolution of tumor growth and the invasive patterns in white and gray matter via mediators such as IFN-beta and TGF-beta. We investigated the effect of normalizing the immune environment on glioma growth by applying a therapeutic antibody and developed several strategies for eradication of tumor cells by neutrophil-mediated transport of nanoparticles. We also developed a strategy of combination therapy (surgery + Trojan neutrophils) for effective control of the infiltration of the glioma cells in one hemisphere before crossing the corpus callosum (CC) in order to prevent recurrence in the other hemisphere. This alternative approach compared to the extended resection of the glioma including CC or butterfly GBM may provide the greater anti-tumor efficacy and reduce side effects such as cognitive impairment.

Asthma-mediated control of optic glioma growth via T cell-microglia interactions: A mathematical model

Schedule: July 8 15:30-16:00 Room 433

Donggu Lee

Konkuk University, Korea

Co-Author(s): Sean Lawler, Yangjin Kim

Abstract:

Optic glioma, a slow-growing tumor, is associated with Neurofibromatosis type 1 (NF1) mutations and increased midkine (MDK) production. A connection between asthma and optic glioma has previously been observed, but the mechanisms are unclear. To elucidate the role of asthma in the regulation of glioma formation, we investigated the role of T cells and the subsequent pathways in the regulation of microglia, a key player in the glioma tumor microenvironment (TME). While asthma is often linked to chronic inflammation, our mathematical analysis and experimental evidence suggest that inflammation can play a key role in suppressing the proliferation of optic glioma cells via immune reprogramming of T cells and the delicate control of signaling networks in microglia. Our mathematical model unveils the complex interactions between tumor and immune cells in optic glioma. Our results indicate that asthma-induced T cell reprogramming inhibits tumor growth by promoting the release of decorin and a subsequent suppression of CCR8 and the intercellular binding kinetics in microglia, followed by blocking of CCL5 production in TME via suppression of NFkB. We developed anti-cancer strategies by leveraging this asthma-induced immune regulation.

Beyond homogeneity: Assessing the validity of the Michaelis-Menten rate law in spatially heterogeneous environments

Schedule: July 8 17:00-17:30 Room 433

Seunggyu Lee

Korea University, Korea

Abstract:

The Michaelis-Menten (MM) rate law has been a fundamental tool in describing enzyme-catalyzed reactions for over a century. When substrates and enzymes are homogeneously distributed, the validity of the MM rate law can be easily assessed based on relative concentrations: the substrate is in large excess over the enzyme-substrate complex. However, the applicability of this conventional criterion remains unclear when species exhibit spatial heterogeneity, a prevailing scenario in biological systems. Here, we explore the MM rate law's applicability under spatial heterogeneity by using partial differential equations. In this study, molecules diffuse very slowly, allowing them to locally reach quasi-steady states. We find that the conventional criterion for the validity of the MM rate law cannot be readily extended to heterogeneous environments solely through spatial averages of molecular concentrations. That is, even when the conventional criterion for the spatial averages is satisfied, the MM rate law fails to capture the enzyme catalytic rate under spatial heterogeneity. In contrast, a slightly modified form of the MM rate law, based on the total quasi-steady state approximation (tQSSA), is accurate. Specifically, the tQSSA-based modified form, but not the original MM rate law, accurately predicts the drug clearance via cytochrome P450 enzymes and the ultrasensitive phosphorylation in heterogeneous environments. Our findings shed light on how to simplify spatiotemporal models for enzyme-catalyzed reactions in the right context, ensuring accurate conclusions and avoiding misinterpretations in *in silico* simulations.

An Age-Structured and Renewal Perspective on Metastatic Growth

Schedule: July 7 17:00-17:30 Room 433

GEORGIOS LOLAS

INCELLIA, Greece

Co-Author(s): Lolas, Georgios, Gavriiadis, Panagiotis, & Matsoukas, Themis

Abstract:

We revisit the classical Iwata--Kawasaki--Shigesada model of metastatic dissemination by reformulating it in terms of lesion age rather than tumor size. Whereas the original framework classifies metastases according to size, size alone does not fully capture the biological history of a lesion: tumors of similar size may differ markedly in their age, growth trajectory, and capacity to generate further metastatic spread. By taking lesion age as the principal structuring variable, we obtain a formulation that is both mathematically more tractable and biologically more informative. This shift in perspective transforms the original size-structured transport equation into an age-structured model with a simpler and more transparent structure. The resulting formulation preserves the behavior of the classical model over clinically relevant time scales, while improving computational efficiency and interpretability. In particular, it clarifies how metastatic burden accumulates over time, how newly seeded lesions contribute to the evolving population, and how a relatively small number of clinically visible metastases may coexist with a much larger, occult population of microscopic disease. We further prove that the age-structured formulation is exactly equivalent to a renewal equation governing the production of new metastases. This equivalence makes the system amenable to direct analytical treatment. In the case of Gompertzian growth and power-law metastatic emission, the model yields explicit results for the asymptotic expansion of the metastatic population and provides a natural framework for the analysis of long-time behavior and detection thresholds. Overall, the age-based reformulation offers a transparent, biologically meaningful, and computationally efficient framework linking primary tumor growth, metastatic seeding, and the emergence of clinically detectable disease.

A cell-based mathematical model for meniscus tissue regeneration

Schedule: July 7 17:30-18:00 Room 433

Nishith NM Mohan

RPTU Kaiserslautern-Landau, Germany

Co-Author(s): Shimi Chettiparambil Mohanan, Nishith Mohan and Christina Surulescu

Abstract:

We propose and analyze a haptotaxis model for mensicus tissue regeneration, obtained by parabolic upscaling from kinetic transport equations written for the mesoscopic densities of mesenchymal stem cells and chondrocytes, which evolve in an artificial scaffold impregnated with hyaluron. We establish global existence of classical solutions to the coupled macroscopic system and investigate the qualitative behavior of solutions through stability and bifurcation analysis. They reveal that haptotaxis mechanisms primarily drive the emergence of spatial patterns. Numerical simulations further illustrate the influence of varying tactic sensitivities and initial configurations on the spatio-temporal evolution of the system.

Decoding Genetically Encoded Wiring Principles of the Brain from Connectome and Spatial Transcriptome Data

Schedule: July 8 14:00-14:30 Room 433

Honda Naoki

Nagoya University, Japan

Co-Author(s): Honda Naoki and Jigen Koike

Abstract:

How genetically encoded molecular patterns shape brain-wide neural wiring remains a fundamental question in neuroscience. To address this, we developed SPERRFY (Spatial Positional Encoding for Reconstructing Rules of axonal Fiber connectivitY), a data-driven framework that integrates connectome data with spatial transcriptome data to infer latent positional gradients underlying neural connectivity. Using mouse brain data from the Allen Brain Atlas, SPERRFY analyzes paired gene-expression profiles at the source and target regions of anatomical projections by canonical correlation analysis. This approach identifies multiple gradient pairs that explain major features of the connectome, spanning both global and local organization. Neural connectivity reconstructed from the inferred gradients shows strong predictive performance and substantially outperforms reconstruction based on physical distance alone. Comparison with null models further supports the biological relevance of the extracted structure. By linking the inferred gradients to individual genes, SPERRFY also provides candidate molecular determinants of wiring specificity. These results extend the classical chemoaffinity concept from topographic circuits to whole-brain connectivity and provide a general framework for decoding genetically encoded design principles of brain architecture.

Towards Data-Driven Modeling of Cell Cycle and Wound Closure Processes

Schedule: July 8 8:30-9:00 Room 433

Qiyao (Alice) Q Peng

Lancaster University, England

Co-Author(s): Erik Blom, Leah Pomfret, Richard Mort and Stefan Engblom

Abstract:

Effective wound repair treatments rely on a clear picture of how cell proliferation and migration are coordinated during tissue restoration. Fibroblasts are key contributors to tissue restoration in the dermis, and modern imaging tools allow their cell-cycle progression to be observed directly, enabling comparison between experiments and computational models. Here we investigate how different stages of the cell cycle influence fibroblast-driven wound closure using the Discrete Laplacian Cell Mechanics (DLCM) framework driven by time-lapse microscopy data. In vitro assays provide cell positions, migration behaviour, and cycle-stage information, and we show that incorporating proliferation, migration, and cell cycle arrest allows the computational model to reproduce the essential experimental trends. The results reveal that arrest in the G1 phase notably impacts the cell cycle dynamics and that the initial spatial arrangement of cycle states significantly affects wound closure. By linking single-cell cycle dynamics with emergent tissue behaviour this work establishes a quantitative approach for exploring how intracellular processes shape repair processes. More broadly, it demonstrates the value of integrating high-resolution data with cell-based mechanical models and provides a foundation for systematic in silico evaluation of therapeutic interventions.

Data driven mathematical modeling of immune cells interactions in tissues

Schedule: July 8 14:30-15:00 Room 433

Leili Shahriyari

University of Massachusetts Amherst, USA

Abstract:

In this talk, I present a computational approach to precision oncology that combines mechanistic modeling with modern machine learning to build predictive digital twins; patient- and subgroup-specific models that forecast tumor progression and response to therapy. Our foundation is quantitative systems pharmacology (QSP) modeling, where tumor immune dynamics are represented as systems of differential equations. We parameterize these models using patient observations and introduce a clustered inference strategy that stratifies individuals by immune profiles and estimates mechanistic parameters within each cluster. This reduces heterogeneity, improves identifiability, and yields interpretable subgroup phenotypes that link immune state to dynamical behavior. A distinguishing aspect of our evaluation is out-of-treatment generalization: we calibrate tumor growth and immune dynamics without fitting treatment response data, then use the resulting mechanistic parameters to predict outcomes under therapy. This design sharpens the scientific test of the model and targets the real-world challenge of predicting under new regimens. I then describe a digital twin platform that operationalizes this pipeline.

Modeling Tumor-Immune Interactions in the Glioblastoma Microenvironment

Schedule: July 7 18:00-18:30 Room 433

Tracy Stepien

University of Florida, USA

Co-Author(s): Lucy Allan, Gillian Carr, Gregory P. Takacs, Jeffrey K. Harrison

Abstract:

Glioblastoma (GBM) is an aggressive brain tumor that is extremely fatal with no current treatment options available that can achieve remission. One potential explanation for minimally effective treatments is due to the characteristically high immune-suppressive glioma microenvironment. We develop an agent-based model to simulate the interactions of glioma cells, T cells, and myeloid-derived suppressor cells (MDSCs) and the effects of oxygen, a T cell chemoattractant, and an MDSC chemoattractant. To validate our model and quantify cell clustering patterns in GBM, we use spatial statistics comparing simulations to data extracted from cross-sectional tumor images of cellular biomarkers.

Novel 3D multiscale advancements in modelling Glioblastoma invasion and relapse

Schedule: July 8 8:00-8:30 Room 433

Dumitru Trucu

University of Dundee, Scotland

Abstract:

Recognising that the complexity of Glioblastoma (GBM) progression requires ever more sophisticated cross-scale interlinked processes to be considered in our modelling approaches, in this work we propose three novel advancements of the multiscale moving boundary framework introduced and established in Trucu et al. 2013 (<https://doi.org/10.1137/110839011>) and further developed in Robyn and Trucu 2019 (<https://doi.org/10.1007/s11538-019-00598-w>) and Szabolcs Suveges et al. 2021 (<https://doi.org/10.3390/math9182214>) by which the presence of the extracellular matrix fibres present at the interface is accounted for alongside with the availability of nutrients within sensing regions of the GBM cells. These will not only enable us to determine more realistic laws for the tumour boundary movement, but also to explore non-local go-or-grow collective cell motility behaviours arising within the bulk of the tumour, as well as to formulate mathematical the emergence of isotropic-to-anisotropic transition within the GBM cell population transport during the invasion of the surrounding brain tissue. These framework developments allow us to explore the emergence of cellular stress caused by both hypoxic behaviour and GBM treatment that lead to acquiring resistance and result in GBM relapse. This further addressed by considering the impact that key metabolic components have over the GBM progression and relapse in the presence treatment.

Mathematical Issues in Mechanical Models for Cells and Tissues

Schedule: July 8 16:30-17:00 Room 433

Fred Vermolen

University of Hasselt, Belgium

Abstract:

Some cells like muscle cells, cancer cells, fibroblasts and myofibroblasts exert forces on their direct environment. Cells exert these forces because of rapid wound closure, to contract muscles or to migrate to other part of the body. Therefore, it is important to consider elastic effects in the tissue surrounding the cells. In this talk, we consider various formalisms for the impact of cellular forces in terms of the immersed interface method, as well as various constitutive equations that involve visco-elastic effects that are combined with microstructural changes.

Special Session 181 : Dirichlet Forms and Related Topics

Organizer(s): Toshihiro Uemura , Panki Kim , Daniel Lenz

Introduction: The theory of Dirichlet forms has evolved into a robust framework bridging probabilistic and analytic potential theory, providing essential tools for analysis on non-smooth spaces. This session focuses on recent foundational advances and broad applications across three interconnected areas. First, we address the analysis of local and non-local operators, with particular attention to heat kernel estimates and regularity theory for integro-differential equations and anomalous diffusion. Topics include the fine properties of transition densities and the behavior of associated jump processes. Second, we feature the versatility of Dirichlet forms in discrete settings and approximation theory, covering spectral geometry on graphs as well as the numerics of SDEs in finite dimensions. We also explore the convergence of Dirichlet forms, providing a rigorous basis for approximating continuous models by discrete ones. Finally, the session encompasses (stochastic) homogenization, investigating the effective properties of operators in complex heterogeneous media from both probabilistic and PDE perspectives. We aim to discuss asymptotic behaviors and multiscale problems in random environments. By integrating these themes, the session aims to deepen the interplay between stochastic analysis and differential equations, fostering collaboration among researchers in these fields.

Feller property and convergence for semi-groups of time-changed processes

Schedule: July 7 18:30-19:00 Room 821

Ali BenAmor

University of Sousse, high school for transport and logistics, Tunisia

Co-Author(s): Kazuhiro Kuwae

Abstract:

We give a substitute to the Feller property for semigroups of time-changed processes; under some conditions this leads to sufficient (new) conditions for the semigroups to be Feller. Moreover, given a standard process and a sequence of measures converging vaguely to a final measure, under some assumptions, we establish convergence of the sequence of the semigroups and the resolvents of the corresponding time changed-processes. .

Fractional Laplacian in Angular Momentum Channels

Schedule: July 7 Room 821

Krzysztof Bogdan

Wroclaw University of Science and Technology, Poland

Abstract:

When the heat semigroup generated by the Laplacian is restricted to angular momentum channels, its decay improves with increasing angular momentum. I will discuss an analogous phenomenon for fractional Laplacians. The improvement is captured by channel-dependent Hardy inequalities and by effective radial heat kernels, which reflect the additional repulsion (killing) induced by the angular momentum (oscillations). This is joint work with Konstantin Merz and Tomasz Jakubowski. A preprint is available on arXiv: <https://arxiv.org/search/?searchtype=author&query=Bogdan%2C+K>

Regularization of the superposition principle: Potential theory meets Fokker-Planck equations

Schedule: July 8 14:00-14:30 Room 821

Iulian Cîmpean

University of Bucharest, Faculty of Mathematics and Computer Science, and Romanian Academy, Romania

Co-Author(s): Lucian Beznea, Michael Roeckner

Abstract:

For a solution to a nonlinear Fokker-Planck equation (FPE) the powerful superposition principle renders a probability measure on path space with one dimensional time marginals equal to this solution, and additionally solving the martingale problem for the Kolmogorov operator given by the FPE. The superposition principle thus reveals that such parabolic PDEs have a probabilistic counter part. The aim of this talk is to go a substantial further step and, by exploiting the superposition principle, Dirichlet forms, and potential theoretic tools, construct a full fledged Markov process, i.e. a family of path space measures for a large set of space time starting points connected by the Markov property, associated to the (linearized) FPE in the above way. Under very general (merely measurability) conditions on the coefficients of the FPE this is achieved in this paper in such a way that the resulting process is a right process. Furthermore, we introduce a Choquet capacity for such FPEs using the corresponding right process. A main application here is the FPE given by the generalized porous media equation and its corresponding McKean-Vlasov SDE.

Construction of distorted Brownian motion with permeable sticky behaviour on sets with Lebesgue measure zero

Schedule: July 8 13:30-14:00 Room 821

Martin Grothaus

RPTU University Kaiserslautern-Landau, Germany

Co-Author(s): Torben Fattler, Nathalie Steil

Abstract:

The starting point is a gradient Dirichlet form with respect to λ^d_ϱ on the space $L^2(\mathbb{R}^d, \mu_\varrho)$. Here λ^d is the Lebesgue measure on $\mathbb{R}^d$, ϱ a strictly positive density and μ_ϱ puts weight on a set $A \subset \mathbb{R}^d$ with Lebesgue measure zero. We show that the Dirichlet form admits an associated stochastic process X . We derive an explicit representation of the corresponding generator if A is a Lipschitz boundary. This representation together with the Fukushima decomposition identifies X as a distorted Brownian motion with drift given by the logarithmic derivative of ϱ in $\mathbb{R}^d \setminus A$. Furthermore, we prove X to be irreducible and recurrent. Finally, via ergodicity we show positive sojourn time of X on A . Hence we obtain a stochastic process X with permeable sticky behaviour on A .

Beurling--Deny formula for Sobolev--Bregman forms

Schedule: July 8 9:30-10:00 Room 821

Michał Gutowski

Wrocław University of Science and Technology, Poland

Co-Author(s): Mateusz Kwaśnicki

Abstract:

For an arbitrary regular Dirichlet form $\mathcal{E}$ and the associated symmetric Markovian semigroup T_t , we consider the corresponding Sobolev--Bregman form $\mathcal{E}_p[u] := \lim_{t \rightarrow 0^+} \frac{1}{t} \|\angle u - T_t u, u\|_{\mathcal{E}}^{p-2} \angle$, where $p \in (1, \infty)$. The Sobolev--Bregman form describes the rate of decrease of the L^p norm of $T_t u$ with respect to time: we have $\mathcal{E}_p[u] = -\frac{1}{p} \frac{d}{dt} \|T_t u\|_p^p \big|_{t=0}$. When $p=2$, $\mathcal{E}_p$ coincides with the original Dirichlet form $\mathcal{E}$. Therefore, the Sobolev--Bregman form can be treated as a L^p -extension of the Dirichlet form. The celebrated Beurling--Deny formula provides a decomposition of a regular Dirichlet form $\mathcal{E}$ into the strongly local term $\mathcal{E}^c$, the purely nonlocal part given in terms of the jumping kernel J , and the killing term described by the killing measure κ . It is well known that there is a one-to-one correspondence between the class of regular Dirichlet forms $\mathcal{E}$ and the class of symmetric Hunt processes (strong Markovian, quasi-left continuous with càdlàg paths). The three parts of the Beurling--Deny decomposition describe the local, jumping, and killing behaviour of the process. The aim of the talk will be to provide a similar decomposition of the corresponding Sobolev--Bregman form. The talk is based on joint work with Mateusz Kwaśnicki (Wrocław University of Science and Technology).

Decay of resolvent kernels and Schrödinger eigenstates for Lévy operators

Schedule: July 8 8:00-8:30 Room 821

Kamil Kaleta

Wrocław University of Science and Technology, Poland

Abstract:

I will present results obtained jointly with R. Schilling (Dresden) and P. Sztonyk (Wrocław) on the spatial decay of resolvent kernels for a broad class of non-local Lévy operators, as well as on eigenfunctions of the associated Schrödinger operators [B]. Our results lead to general theorems concerning Lévy measures with exponential and subexponential decay at infinity. In particular, we identify sharp qualitative transitions in these decay properties, thereby extending classical results of Carmona, Masters, and Simon [A] for the fractional Laplacian (subexponential decay) and relativistic operators (exponential decay). Moreover, these transitions in eigenfunction decay admit a natural energetic interpretation, which will also be discussed during the talk. References: [A] R. Carmona, W. C. Masters, and B. Simon, Relativistic Schrödinger operators: asymptotic behavior of the eigenfunctions, J. Funct. Anal. 91(1) 117--142 (1990) [B] K. Kaleta, R.L. Schilling, P. Sztonyk, Decay of resolvent kernels and Schrödinger eigenstates for Lévy operators, Math. Ann. 394(4), 88 (2026)

On quasi-ergodic limits for symmetric Markov processes

Schedule: July 8 15:00-15:30 Room 821

Daehong Kim

Kumamoto University, Japan

Co-Author(s): Yiming Zhou

Abstract:

We characterize quasi-ergodic limiting measures for additive functionals of a symmetric Markov process X . We consider two types of additive functionals beyond the classical occupation-time setting: continuous additive functionals associated with Revuz measures and purely discontinuous additive functionals. Our results do not require the finiteness of the total mass of the underlying measure nor (intrinsic) ultracontractivity of the semigroups, assumptions commonly imposed in the existing literature. As a consequence, we establish Chacon-Ornstein type ratio ergodic limits for additive functionals of X .

Non-local Feynman-Kac perturbations for jump diffusions on metric measure spaces

Schedule: July 8 8:30-9:00 Room 821

Kyung-Youn Kim

National Chung-Hsing University/Applied Mathematics, Taiwan

Co-Author(s): Zhen-Qing Chen; Lidan Wang

Abstract:

We establish the stability of two-sided heat kernel estimates for a class of (possibly non-symmetric) jump diffusions on metric measure spaces under non-local Feynman-Kac perturbations. Moreover, we obtain parabolic Harnack inequality and Holder regularity for parabolic functions of the non-local Schrodinger operators of the jump diffusions.

Intrinsic geometry of multivariate L^∞ measures and weak solutions to L^∞ driven SDEs

Schedule: July 8 16:30-17:00 Room 821

Oleksii Kulyk

Wroclaw University of Science and Technology, Poland

Co-Author(s): Tadeusz Kulczycki, Michal Ryznar

Abstract:

We introduce the notion of the concentration function for multi-dimensional L^∞ measures and related notions of level sets, concentration sets, and concentration norms. We will present a systematic study of the concentration and heat kernel properties of multivariate L^∞ processes based on these geometry notions. This study is originated in our previous research of SDEs driven by spatially heterogeneous L^∞ noises. We will present a general approach for getting weak existence/uniqueness and heat kernel estimates for solutions of L^∞ driven SDEs with the assumptions on the coefficients given in the terms of the intrinsic geometry of the driving noise, which unifies and extends considerably the previously available results.

A remark on subharmonicity for symmetric Dirichlet forms

Schedule: July 7 18:00-18:30 Room 821

Kazuhiro Kuwae

Fukuoka University/Department of Applied Mathematics, Japan

Co-Author(s): Rong Lei and Ludovico Marini

Abstract:

We remove the local boundedness for $\mathcal{E}_{\alpha}$ -subharmonicity in the framework of (not necessarily strongly local) regular symmetric Dirichlet form $(\mathcal{E}, D(\mathcal{E}))$ with $\alpha \geq 0$ and establish the stochastic characterization for $\mathcal{E}$ -subharmonic functions without assuming the local boundedness.

Emergence of an unsaturated Darcy's law and a Richards-type equation via homogenization of the Stokes-Cahn-Hilliard system

Schedule: July 8 15:30-16:00 Room 821

Jun Masamune

Kyoto University, Japan

Abstract:

We study the homogenization of a microscopic Stokes-Cahn-Hilliard system in a periodically perforated porous medium with logarithmic free energy. The model describes incompressible two-phase flow with diffuse interfaces inside pore-scale geometries and incorporates capillary effects through the chemical potential. This is a collaborative effort with Rong Lei at Tohoku University.

On the Markov property of subsequential limits for a sequence of Markov chains

Schedule: July 8 9:00-9:30 Room 821

Kouhei Matsuura

University of Tsukuba, Japan

Abstract:

In this talk, we consider a sequence of Markov chains defined on point sets in a Euclidean domain and discuss sufficient conditions for its subsequential limits to possess the Markov property. Establishing the Markov property is important, as it implies that the limit generates a symmetric Dirichlet form under appropriate additional conditions including the symmetry of each chain, which in turn allows for characterizing the limit through concepts such as the Silverstein extension. We also discuss conditions under which the subsequential limit becomes a reflected Brownian motion on the domain, as well as a framework applicable to more general Markov processes.

Topological properties of the Revuz correspondence

Schedule: July 8 14:30-15:00 Room 821

Takumu Ooi

Tokyo University of Science, Japan

Co-Author(s): Kaneharu Tsuchida and Toshihiro Uemura

Abstract:

We investigate topological properties of the Revuz correspondence. We provide necessary and sufficient conditions for the convergence of Revuz measures of finite energy integrals. In this setting, we show that the Revuz map, restricted to the class of finite energy integrals equipped with the norm induced by a Dirichlet form, is a homeomorphism when the space of positive continuous additive functionals is endowed with the topology induced by $L^2(P_{m+\kappa+\nu_0})$ -norm together with the local uniform topology, where m is the underlying measure, κ is the killing measure and ν_0 is an energy functional of a Hunt process. We also present a characterization of the Revuz correspondence in terms of killing of the process and further consider continuity properties of the Revuz correspondence for broader classes.

Subharmonic functions and the BMS conjecture for regular Dirichlet forms

Schedule: July 7 17:30-18:00 Room 821

Marcel Schmidt

Friedrich-Schiller-University Jena, Germany

Abstract:

In this talk we discuss several notions of subharmonic functions in the context of regular Dirichlet forms. A particular emphasis is put on their regularity. We extend recent results by G\uneysu, Pigola, Stollmann and Veronelli '24 to a class of possibly non-local Dirichlet forms and put their attempt at subharmonic functions via so-called locally shift defective functions into perspective. The Bravermann, Milatovic, Shubin conjecture (BMS conjecture, recently confirmed by Pigola, Veronelli '21) asks, whether on a complete Riemannian manifold, for $f \in L^2(M)$ the distributional inequality $|\Delta f| \leq f$ implies $f \geq 0$. We use our regularity theory for subharmonic functions to verify the validity of this conjecture for a large class of 'distributional operators' derived from regular Dirichlet forms.

Dirichlet problem for Lane--Emden type equations with several sublinear terms

Schedule: July 8 17:00-17:30 Room 821

Adisak Seesanea

Sirindhorn International Institute of Technology, Thammasat University, Thailand

Abstract:

We present the existence, uniqueness, and sharp bilateral pointwise estimates for positive bounded solutions to the Lane--Emden type problem
$$\begin{cases} \mathcal{L} u = \sum_{i=1}^m \sigma_i u^{q_i} + \sigma_0, & u \geq 0 \\ & \text{in } \Omega, \\ \liminf_{x \rightarrow y} u(x) = f(y), & y \in \partial \Omega, \end{cases}$$
 where $0 < q_i < 1$. Here $\mathcal{L} u = -\operatorname{div}(\mathbb{A} \nabla u)$ is a uniformly elliptic operator with bounded coefficients, σ_i is a nonnegative locally finite Borel measure on an $\mathbb{A}$ -regular domain $\Omega \subset \mathbb{R}^n$ which possesses a positive Green function associated with $\mathcal{L}$, and f is a nonnegative continuous function on the boundary $\partial \Omega$. An analogous result for positive continuous solutions to the problem is also illustrated. Our method can be adapted to address related sublinear problems with zero boundary conditions involving the fractional Laplace operator $(-\Delta)^\alpha$ for $0 < \alpha < n/2$, in place of $\mathcal{L}$, in $\mathbb{R}^n$ as well. This is a joint work with Kentaro Hirata (Hiroshima) and Toe Toe Shwe (SIIT).

Strongly continuous fields of operators over varying Hilbert spaces

Schedule: July 8 17:30-18:00 Room 821

Peter R.M Stollmann

TU Chemnitz, Germany

Co-Author(s): Ali BenAmor, Batu G\uneysu, Thomas Kalmes

Abstract:

After introducing a natural notion of continuous fields of locally convex spaces, we establish a new theory of strongly continuous families of possibly unbounded self-adjoint operators over varying Hilbert spaces. This setting allows to treat operator families defined on bundles of Hilbert spaces that are not locally trivial (such as e.g. the tangent bundle of Wasserstein space), without referring to identification operators at all.

Homogenization of Non-Symmetric Pure Jump Processes on a Bounded Domain

Schedule: July 7 17:00-17:30 Room 821

Toshihiro Uemura

Department of Mathematics, Kansai University, Japan

Abstract:

We consider the periodic homogenization of non-symmetric pure jump processes (α -stable-like processes with $1 < \alpha < 2$) on a bounded $C^{1,1}$ domain of $\mathbb{R}^d$. Under appropriate conditions on the jumping kernels, we establish the Mosco-Hino convergence of the corresponding semi-Dirichlet forms. By exploiting the asymptotic decoupling of microscopic fluctuations, our unified framework bypasses the technical difficulties associated with explicit correctors.

Dirichlet Forms with Jump Kernels Decaying at the Boundary

Schedule: July 7 16:30-17:00 Room 821

Zoran Vondracek

University of Zagreb and SOIS-FT, Croatia

Co-Author(s): S.Cho, P.Kim, R.Song

Abstract:

In this talk, I will give an overview of recent results concerning Dirichlet forms and the associated singular nonlocal operators whose kernels vanish at the boundary of a smooth subset of Euclidean space. I will describe the motivation for this line of research, explain the methods - combining probabilistic and analytic techniques - and present the main results, highlighting how they differ from the classical ones.

Special Session 182 : Recent developments on mathematical finance, stochastic control and related topics

Organizer(s): Zhenhua Wang , Zhou Zhou , Jingjie Zhang

Introduction: Stochastic control provides a fundamental framework for modeling dynamic decision-making under uncertainty and has become central to modern research in mathematical finance, economics, and machine learning, and related disciplines. Recent years have witnessed significant advances motivated by complex market dynamics, behavioral features, and strategic interactions among multiple agents. This special session aims to bring together researchers working on theoretical, computational, and applied aspects of stochastic control and its connections to mathematical finance. Topics of interest include, but are not limited to: option pricing and portfolio selection, stochastic analysis, stochastic control and games in finance and economics, and reinforcement learning.

Distribution constrained optimal stopping: beyond the Root-type solution

Schedule: July 6 14:00-14:30 Room 620

Shuoqing Deng

The Hong Kong University of Science and Science and Technology, Hong Kong

Co-Author(s): Shuoqing Deng

Abstract:

We give an explicit construction of the boundary which solves the distribution constrained optimal stopping when the cost function is not of Root-type. The boundary can be characterised analytically and probabilistically. From the analytical perspective, it is characterised by the viscosity solution of a variational inequality with Wentzell type boundary condition. From the probabilistic perspective, it can be characterised by the backward optimal stopping of a Sticky Brownian motion without distribution constraint.

Pricing and Hedging of SOFR Derivatives

Schedule: July 6 14:30-15:00 Room 620

Yining Ding

The University of Sydney, Australia

Co-Author(s): Matthew Bicksteth, Yining Ding, Marek Rutkowski

Abstract:

The London Interbank Offered Rate (LIBOR) has served since the 1970s as a fundamental measure for floating term rates across multiple currencies and maturities. However, in 2017, the Financial Conduct Authority announced the discontinuation of LIBOR from the end of 2021, and the New York Fed declared the Treasury repo financing rate, called the Secured Overnight Financing Rate (SOFR), as a candidate for a new reference rate for IRSs denominated in U.S. dollars. We examine arbitrage-free pricing and hedging of swaps referencing SOFR without and with collateral backing. As hedging instruments, we take SOFR futures and idiosyncratic funding rates for the hedge and margin account. For simplicity, a one-factor model based on Vasicek's equation is used to specify the joint dynamics of several overnight interest rates, including the SOFR and unsecured funding rate.

Dynamic Portfolio Selection under Monotone Additive Statistics in the Heston Model

Schedule: July 6 13:30-14:00 Room 620

Xuedong He

Chinese University of Hong Kong, Hong Kong

Co-Author(s): Zhaoli Jiang, Jianming Xia

Abstract:

The monotone additive statistic is a preference representation satisfying the monotonicity and additivity properties. This statistic has been proven to be represented by a weighted average of certainty equivalents under exponential utility functions with different risk aversion degrees and employed in various financial and economic contexts. We study a dynamic portfolio selection problem in which an agent trades a risk-free asset and a risky stock with stochastic volatility to optimize her investment performance measured by the monotone additive statistic of her terminal wealth or log investment return. We find that the monotone additive statistic, when applied to dynamic decision problems, can lead to time inconsistency. We thus consider equilibrium strategies for our portfolio selection problem and derive these strategies by proving the solvability of two associated systems of ordinary differential equations.

Merton's Problem with Recursive Perturbed Utility

Schedule: July 6 17:00-17:30 Room 620

Yanwei Jia

The Chinese University of Hong Kong, Hong Kong

Co-Author(s): Min Dai, Yuchao Dong, Yanwei Jia, Xunyu Zhou

Abstract:

The classical Merton investment problem predicts deterministic, state-dependent portfolio rules; however, laboratory and field evidence suggest that individuals often prefer randomized decisions leading to stochastic and noisy choices. Fudenberg et al. (2015) develop the additive perturbed utility theory to explain the preference for randomization in the static setting, which, however, becomes ill-posed or intractable in the dynamic setting. We introduce the recursive perturbed utility (RPU), a special stochastic differential utility that incorporates an entropy-based preference for randomization into a recursive aggregator. RPU endogenizes the intertemporal trade-off between utilities from randomization and bequest via a discounting term dependent on past accumulated randomization, thereby avoiding excessive randomization and yielding a well-posed problem. In a general Markovian incomplete market with CRRA preferences, we prove that the RPU-optimal portfolio policy (in terms of the risk exposure ratio) is Gaussian and can be expressed in closed form, independent of wealth. Its variance is inversely proportional to risk aversion and stock volatility, while its mean is based on the solution to a partial differential equation. Moreover, the mean is the sum of a myopic term and an intertemporal hedging term (against market incompleteness) that intertwines with policy randomization.

Vulnerable European and American Options in a Market Model with Optional Hazard Process

Schedule: July 6 17:30-18:00 Room 620

Ruyi Liu

University of New South Wales, Australia

Abstract:

Vulnerable options of a European and American style with a possible occurrence of an exogenous termination are studied under market incompleteness in a hazard process setup. It is proven that the reduced upper price of a vulnerable European option coincides with the unique price of an American option with a properly defined payoff and holder's exercise times constrained to the random set given by the right support of the hazard process. For a vulnerable American option, it is shown that the reduced upper price equals the price of a specific American option with unrestricted exercise times, whereas the reduced lower price coincides with the price of a particular game option in which the issuer's exercise times are constrained to the above-mentioned random set.

Risk-sensitive Reinforcement Learning based on Convex Scoring Functions

Schedule: July 7 14:00-14:30 Room 620

Yang Liu

The Chinese University of Hong Kong, Shenzhen, Peoples Rep of China

Co-Author(s): Shanyu Han, Yang Liu, Xiang Yu

Abstract:

We propose a reinforcement learning (RL) framework under a broad class of risk objectives, characterized by convex scoring functions. This class covers many common risk measures, such as variance, Expected Shortfall, entropic Value-at-Risk, and mean-risk utility. To resolve the time-inconsistency issue, we consider an augmented state space and an auxiliary variable and recast the problem as a two-state optimization problem. We propose a customized Actor-Critic algorithm and establish some theoretical approximation guarantees. A key theoretical contribution is that our results do not require the Markov decision process to be continuous. Additionally, we propose an auxiliary variable sampling method inspired by the alternating minimization algorithm, which is convergent under certain conditions. We validate our approach in simulation experiments with a financial application in statistical arbitrage trading, demonstrating the effectiveness of the algorithm.

Inverse Learning the Altruism and Labor Cost Level in Mixed-Individual Mean Field Games

Schedule: July 6 18:00-18:30 Room 620

Xiaofei Shi

University of Toronto, Canada

Co-Author(s): Haoyang Cao, Gokce Dayanikli

Abstract:

Understanding how humans respond to incentives, both individually and collectively, is central to effective policy design. In the context of stochastic differential game, mean field games (MFGs) are usually used to capture interactions among fully non-cooperative (egocentric) players, whereas mean field control (MFC) models are to study fully cooperative (altruistic) players. To capture the whole spectrum of behaviors, mixed-individual MFGs introduce a parameterized blend of egocentric and altruistic objectives. However, in practical settings policymakers cannot directly observe intrinsic altruism levels and/or other private cost parameters such as cost of efforts. We address this challenge by developing an inverse learning framework for mixed-individual MFGs. We demonstrate the feasibility and accuracy of the method through numerical experiments, showcasing recovery of latent altruism levels under noisy observations. Our results highlight the potential of inverse MFG techniques to infer behavioral structure in large populations, with implications for incentive design and data-driven policy analysis.

Incentives of Defined-Contribution Pension Managers

Schedule: July 7 15:30-16:00 Room 620

Ho Man Tai

University of Sydney, Australia

Co-Author(s): Paolo Guasoni, Bohan Li, Tak Kwong Wong, Sheung Chi Phillip Yam

Abstract:

This talk will discuss the implications of asset management fee structures for defined-contribution pension funds. We develop a model where a manager with inter-temporal preferences invests pension contributions over members' working lives. Contrary to typical risk-shifting behaviors documented in the literature, we find that managers with the same preferences as plan members take less risk than plan members would choose for themselves. This result is due to the consumption-smoothing motive and the misalignment arising from calculating fees as a proportion of current assets rather than total wealth. Our findings reveal an overlooked aspect of delegated portfolio management and underscore the significance of inter-temporal utility in pension fund management. We establish the well-posedness of the value function and the optimal trading strategy through a fully nonlinear Hamilton-Jacobi-Bellman equation. We also develop an efficient numerical scheme to approximate the solutions, overcoming the challenges associated with its non-linearity and unbounded domain.

Portfolio Optimization under Transaction Costs with Recursive Preferences

Schedule: July 7 14:30-15:00 Room 620

Alex Tse

University College London, England

Co-Author(s): Martin Herdegen; David Hobson

Abstract:

In this talk, I will report some recent progress on the portfolio optimization problem featuring proportional transaction costs under the Epstein-Zin stochastic differential utility preference. A key and novel idea is to parametrise consumption and the value function in terms of the "shadow fraction of wealth", which leads to a simpler first order free boundary problem. This facilitates the analysis of aspects of the problem that have previously been challenging such as well-posedness, comparative statics, and cases beyond the small transaction cost regime. An extension to dividend-paying risky asset will be discussed.

Well-posedness of the equilibrium HJB system for time-inconsistent controls

Schedule: July 6 15:30-16:00 Room 620

Zhenhua Wang

Shandong University, Peoples Rep of China

Co-Author(s): Xiang Yu, Jiengjie Zhang, Zhou Zhou

Abstract:

We provide a general framework to solve equilibrium HJB equation system for time-inconsistent control problems by entropy-regularization. The controlled process is given by a SDE with no control on the diffusion term. We show the existence of solution/equilibrium with positive entropy weight, then prove the existence of relaxed equilibrium to the original time-inconsistent control by vanishing the entropy weight. This talk is based on joint works with Xiang Yu, Jingjie Zhang and Zhou Zhou.

Continuous-time q-learning for mean-field control problems with common noise

Schedule: July 7 15:00-15:30 Room 620

Xiaoli Wei

Harbin Institute of Technology, Peoples Rep of China

Co-Author(s): Zhenjie Ren, Xiang Yu, Xun Yu Zhou

Abstract:

This paper investigates the continuous-time counterpart of the Q-function for entropy-regularized mean-field control (MFC) with controlled common noise, coined as q-function by Jia and Zhou (2023) in the single agent's model. We first show that, under discretely sampled actions, the value function in the exploratory formulation converges to the one in the relaxed control formulation as the time grid refines. Leveraging the relaxed control formulation, we derive the exploratory Hamilton-Jacobi-Bellman (HJB) equation, in which the controlled common noise gives rise to an additional nonlinear functional of policy, rendering the policy iteration intricate. Under certain concavity condition, we establish the existence and uniqueness of the optimal one-step policy iteration via a first-order condition using the partial linear functional derivative with respect to policy. The policy improvement at each iteration is verified by relating to an entropy-regularized optimization problem over the space of policies. In the mean-field setting, we introduce the integrated q-function (Iq-function) defined on the state distribution and the policy, and it is shown that an optimal policy is identified as a two-layer fixed point to the argmax operator of the Iq-function. Finally, we provide the explicit characterization of an optimal policy as a Gaussian distribution in the general linear-quadratic (LQ) setting.

Mean-field games with rough common noise: the compactification approach

Schedule: July 7 17:00-17:30 Room 620

Fengyi Yuan

The Chinese University of Hong Kong (Shenzhen), Peoples Rep of China

Co-Author(s): Erhan Bayraktar, Xihao He, Xiang Yu, Fengyi Yuan

Abstract:

We study mean-field game (MFG) problems with rough common noise where the representative state dynamics is governed by a controlled rough stochastic differential equation driven by an idiosyncratic Brownian motion and a deterministic rough path noise affecting the whole population. Within this new framework, we introduce a canonical weak formulation based on relaxed controls and rough martingale problems. We prove the existence of a pathwise mean-field equilibrium in this context by developing new technical tools for compactification to accommodate rough integration, which deviate substantially from classical compactification arguments in the literature. Finally, we discuss the relationship between the pathwise problem and the classical MFG problem with randomized Brownian common noise: conditioning yields the pathwise problem almost surely; and conversely, under a suitable causality/measurable-selection requirement, pathwise mean-field equilibria can be aggregated to produce randomized mean-field equilibria in the classical problem.

Major-Minor Mean Field Game of Stopping: An Entropy Regularization Approach

Schedule: July 7 17:30-18:00 Room 620

Jiacheng Zhang

the Chinese University of Hong Kong, Hong Kong

Co-Author(s): Xiang Yu, Keyu Zhang, Zhou Zhou

Abstract:

This paper studies a discrete-time major-minor mean field game of stopping where the major player can choose either an optimal control or stopping time. We look for the relaxed equilibrium as a randomized stopping policy, which is formulated as a fixed point of a set-valued mapping, whose existence is challenging by direct arguments. To overcome the difficulties caused by the presence of a major player, we propose to study an auxiliary problem by considering entropy regularization in the major player's problem while formulating the minor players' optimal stopping problems as linear programming over occupation measures. We first show the existence of regularized equilibria as fixed points of some simplified set-valued operator using the Kakutani-Fan-Glicksberg fixed-point theorem. Next, we prove that the regularized equilibrium converges as the regularization parameter λ tends to 0, and the limit corresponds to a fixed point of the original operator, thereby confirming the existence of a relaxed equilibrium in the original mean field game problem. We also extend this entropy regularization method to the mean-field game problem where the minor players choose optimal controls.

Goal-based Portfolio Selection with Fixed Transaction Costs

Schedule: July 6 15:00-15:30 Room 620

Jingjie Zhang

University of International Business and Economics, Peoples Rep of China

Co-Author(s): Erhan Bayraktar, Bingyan Han

Abstract:

We study a goal-based portfolio selection problem in which an investor aims to meet multiple financial goals, each with a specific deadline and target amount. Trading the stock incurs a strictly positive transaction cost. Using the stochastic Perron's method, we show that the value function is the unique viscosity solution to a system of quasi-variational inequalities. The existence of an optimal trading strategy and goal funding scheme is established. Numerical results reveal complex optimal trading regions and show that the optimal investment strategy differs substantially from the V-shaped strategy observed in the frictionless case.

Optimization of win martingales

Schedule: July 7 16:30-17:00 Room 620

Xin Zhang

NYU, USA

Co-Author(s): Julio Backhoff

Abstract:

Prediction market is a market where people can trade based on outcomes of future events. It is widely used in sports games, elections, and pricing of digital options. In math finance, prediction markets can be modeled by the so-called win martingales, which are continuous time martingales that end up with Bernoulli distributions. In this talk, choosing different divergences as objective functionals, we will solve a class of optimal win martingales. In some cases, we will get explicit formulas of optimizers, and make connections to Schrödinger, filtering problems, Wright-Fisher diffusion, and the problem of identifying most exciting games.

EXISTENCE OF EQUILIBRIA FOR TIME-INCONSISTENT GAMES IN DISCRETE TIME

Schedule: July 6 16:30-17:00 Room 620

Zhou Zhou

University of Sydney, Australia

Co-Author(s): Zhou Zhou

Abstract:

We investigate Markov relaxed equilibria for time-inconsistent stochastic games in discrete time. A key feature of such equilibria is that they capture the interaction of the current self with both future selves and other players. Our objective is to establish the existence of equilibria when the state space of the underlying controlled process is uncountable. The main difficulty arises from the absence of topologies under which the strategy sets are compact and the associated value functions are continuous. We provide general conditions on the transition kernels of the underlying process under which existence can be established.

DeepPAAC: A New Deep Galerkin Method for Principal-Agent Problems

Schedule: July 7 18:00-18:30 Room 620

Zimu Zhu

Hong Kong University of Science and Technology (Guangzhou), Peoples Rep of China

Co-Author(s): Michael Ludkovski, Changgen Xie

Abstract:

We consider numerical resolution of principal-agent (PA) problems in continuous time. We formulate a generic PA model with continuous and lump payments and a multi-dimensional strategy of the agent. To tackle the resulting Hamilton-Jacobi-Bellman equation with an implicit Hamiltonian we develop a novel deep learning method: the Deep Principal-Agent Actor Critic (DeepPAAC) Actor-Critic algorithm. DeepPAAC is able to handle multi-dimensional states and controls, as well as constraints. We investigate the role of the neural network architecture, training designs, loss functions, etc. on the convergence of the solver, presenting five different case studies. This is a joint work with Michael Ludkovski and Changgen Xie.

Special Session 183 : Mathematics in Cryptography and Codes

Organizer(s): Anyu Wang , Yang Yu

Introduction: Mathematics provides the foundation for both cryptography and coding theory, two disciplines essential to secure and reliable communication in the digital age. This session, Mathematics in Cryptography and Codes, aims to showcase research that advances or exploits deep mathematical ideas in these areas. We seek contributions that reveal novel connections between abstract mathematical structures and problems in cryptographic design or code construction, as well as works where challenges from these fields stimulate new mathematical inquiry. By bringing together researchers who work at this intersection, the session hopes to highlight the enduring role of rigorous mathematics in addressing fundamental questions of security, privacy, and error resilience—and to foster dialogue that bridges theory and application.

Cryptanalytic Parameter Recovery of Neural Networks: Some Recent Advances

Schedule: July 10 10:30-11:00 Room 312

Yi Chen

Institute of Advanced Study, Tsinghua University, Peoples Rep of China

Abstract:

The problem of model extraction in machine learning has been studied for over thirty years. Its most challenging goal --- functionally equivalent extraction in the black-box setting --- is achieved via parameter recovery. Since Crypto 2020, researchers have made significant progress by approaching it through the lens of cryptanalysis. In this talk, we will briefly review this problem and introduce some recent results in this emerging direction, with a special focus on attacks in the hard-label setting.

Secure Network Function Computation

Schedule:**Xuan Guang**

Nankai University, Peoples Rep of China

Co-Author(s): Xuan Guang, Yang Bai, Raymond W. Yeung

Abstract:

to be updated

Secure Network Function Computation for Linear Functions

Schedule: July 10 11:30-12:00 Room 312

Xuan Guang

Nankai University, Peoples Rep of China

Abstract:

We will introduce the problem of (information-theoretically) secure network function computation. For the problem, a target function, of which the inputs are generated at multiple source nodes, is required to be computed with zero error at a sink node over a network, while a wiretapper, who can access any one but not more than one wiretap set in a given collection of wiretap sets, is not allowed to obtain any information about a security function of the source messages. We are interested in characterizing the secure computing capacity for this problem, which is defined as the maximum average number of times the target function can be securely computed with zero error for one use of the network. In general, the characterization of this secure capacity with this general setup is overwhelmingly difficult. In this talk, we focus on the secure model for linear functions with the wiretapper being able to eavesdrop any subset of edges in the network up to a certain size, referred to as the security level.

A New Configuration for 3rd-FHE Bootstrapping from the Key Switching

Schedule: July 10 12:00-12:30 Room 312

Han Wang

Institute of Information Engineering, CAS, Peoples Rep of China

Abstract:

This work introduces a new configuration of the \$GSW\$ FHE (Gentry, Sahai, Waters~Crypto 2013), with a squared gadget ,batching and scale-based homomorphic operation, from the key switching operations. This configuration offers improved efficiency compared to existing approaches. By utilizing our proposed method as the underlying building block, we can accelerate 3rd-FHE bootstrapping implementations, including the libraries of \$OpenFHE\$ and \$TFHE\$. We conduct comprehensive experiments to evaluate the concrete performance of our method, demonstrating improvements of more than 2 times faster.

New Results on Elliptic Curve Hidden Number Problem for ECDH Key Exchange

Schedule: July 10 13:30-14:00 Room 312

Jun Xu

Institute of Information engineering, CAS, Peoples Rep of China

Co-Author(s): Jun Xu, Santanu Sarkar, Huaxiong Wang, Lei Hu

Abstract:

The Elliptic Curve Hidden Number Problem (EC-HNP) was introduced at Asiacrypt 2001, and its Diffie-Hellman variant proposed at PKC 2017 serves for evaluating ECDH bit security and side-channel cryptanalysis. In this talk, we present the Coppersmith method for solving the multivariate modular polynomials in this variant. For a fixed elliptic curve over $\mathbb{F}_p$ with large prime p , if an oracle returns $\delta/\log_2 p$ fraction of the most (least) significant bits of the ECDH key's x -coordinate, we give a heuristic polynomial-time algorithm in $\log_2 p$ to recover the full secret. Our result allows any constant ratio in $(0,1)$, which improves over the bounds $5/6$ and $1/2$ in earlier works. Although no rigorous ECDH bit security is derived, experiments on NIST curves with small lattices validate the heuristic effectiveness.

A Simple Introduction to Secure Multi-Party Computation

Schedule: July 10 14:30-15:00 Room 312

Cong Zhang

Tsinghua University, Peoples Rep of China

Abstract:

This talk will provide a concise introduction to secure multi-party computation (MPC), covering its fundamental concepts, including the definition of MPC, oblivious transfer (OT), and constructions based on garbled circuits.

Applications of Gaussian Sampling in Cryptography

Schedule: July 10 14:00-14:30 Room 312

Shiduo Zhang

Tsinghua University, Peoples Rep of China

Abstract:

This presentation will systematically explain the application of Gaussian sampling in cryptographic design and the related parameter settings.

Special Session 184 : Mean-Field Games: From Partial Differential Equations to Numerical Methods

Organizer(s): Diogo Gomes , Alpar Meszaros , Marco Cirant

Introduction: This special session focuses on the interplay between the mathematical analysis and the numerical approximation of Mean-Field Games (MFG). The session will cover a broad spectrum of recent advances, ranging from the fundamental theory of MFG systems, including the well-posedness of Master equations, regularity results for Hamilton-Jacobi-Bellman and Fokker-Planck systems, and weak solution concepts based on monotone operator theory, to the rigorous development of computational schemes. Particular attention will be devoted to the interface between PDEs and numerics, with talks on finite element methods, splitting algorithms, and optimization-based approaches for stationary and time-dependent problems, including those with non-smooth Hamiltonians. The session will also explore asymptotic regimes, such as the mean-field limit of interacting particle systems, flocking models, and convergence analysis in the Wasserstein space. By convening experts in partial differential equations, control theory, and numerical analysis, this session aims to address open challenges in designing novel algorithms that preserve the theoretical properties of the underlying mean-field models.

Nonlocal mean field games with pseudomeasure or negative Sobolev initial distributions

Schedule: July 9 9:30-10:00 Room 825

David M. Ambrose

Drexel University, USA

Abstract:

To rigorously take the limit of N -player games as N goes to infinity, one important step is to establish existence of solutions for the mean field games PDE system allowing measure-valued data. To do so, we consider two classes of initial data, each of which has probability measures as a subset. The two classes of data are the space of pseudomeasures, and Sobolev spaces with sufficiently negative regularity index. To allow such rough data, we consider a class of non-separable Hamiltonians which are regularizing with respect to the measure, but which arise naturally in a number of applications. In these Hamiltonians, the measure variable appears only in an integral over the whole spatial domain. We present existence theorems for the mean field games PDE system with these Hamiltonians and these classes of initial data. In the negative Sobolev case, this includes the first-order case, i.e. without diffusion.

Non-asymptotic estimates for differential games with large discount

Schedule: July 8 15:30-16:00 Room 825

Giovanni Carlon

University of Padova, Italy

Co-Author(s): Marco Cirant

Abstract:

In this talk, I will present recent estimates for solutions to systems of PDEs arising as optimality conditions in a class of differential games with large discount, obtained in collaboration with Marco Cirant. The estimates are pointwise and uniform with respect to both the number of players N and the discount factor λ , and they do not rely on any monotonicity assumptions on the cost functions of the players. These results, in turn, allow us to investigate several interesting questions about the equilibria of such games, including the size of the gap between different notions of equilibrium and the limiting behavior as N or λ tend to infinity.

Uniqueness of solutions for MFG with large discount

Schedule: July 8 15:00-15:30 Room 825

Elisa Continelli

University of Padova, Italy

Co-Author(s): Marco Cirant, Nicolò De Bernardi

Abstract:

We deal with a class of Mean Field Games systems with large discount. We show that solutions to these systems are unique provided that the discount factor is sufficiently large, identifying an asymptotic uniqueness regime that falls outside the usual ones involving monotonicity.

A semi-Lagrangian scheme for First-Order Mean Field Games based on monotone operators

Schedule: July 8 9:00-9:30 Room 825

Valentina Coscetti

University of Rome "La Sapienza", Italy

Co-Author(s): Elisabetta Carlini

Abstract:

We construct a semi-Lagrangian scheme for first-order, time-dependent, and non-local Mean Field Games. The convergence of the scheme to a weak solution of the system is analyzed by exploiting a key monotonicity property. To solve the resulting discrete problem, we implement a Learning Value Algorithm, prove its convergence, and propose an acceleration strategy based on a Policy iteration method. Finally, we present numerical experiments that validate the effectiveness of the proposed schemes and show that the accelerated version significantly improves performance.

On the Local Turnpike Property in Mean Field Control and Games

Schedule: July 8 14:30-15:00 Room 825

Nicolò De Bernardi

Università degli Studi di Padova, Italy

Co-Author(s): Marco Cirant

Abstract:

We study the local stability of solutions to ergodic and discounted Mean Field Games systems around stationary equilibria with quadratic Hamiltonians. Inspired by finite-dimensional models, we introduce a new stability assumption which allows for non-monotone local couplings, and show that this weaker condition still ensures a (local) exponential turnpike property for solutions close to the stationary one. We also provide an interpretation of this non-monotonicity assumption in terms of spectral properties of an operator, which might be encoded in the MFG system. This leads to a class of meaningful examples of MFG systems with no monotonicity but still fulfilling our new assumption. This talk is based on joint work with M. Cirant (Padova).

Lipschitz regularity of the trajectories minimizing the total variation in a congested setting

Schedule: July 8 16:30-17:00 Room 825

Annette Dumas

Université de Limoges, XLIM, France

Co-Author(s): Filippo Santambrogio

Abstract:

The problem I will present is motivated by the study of housing dynamics inside a city through a Mean Field Game model. Each agent jumps to move from one place to another and minimizes a cost composed of the number of jumps and an increasing function of the density of the population. A Nash equilibrium is of the form of a probability measure on the set of individual trajectories. This probability measure minimizes a problem which depends on the probability measure itself. By using tools from optimal transport, we will see that the latter problem can be expressed in an Eulerian point of view by minimizing the total variation on the set of curves of measures. The solution to the Eulerian problem exists, is unique and is Lipschitz in time, despite the discontinuous trajectories taken by each agent. With additional hypothesis on the data, boundedness or continuity in space can be obtained with Dirichlet conditions in time. Numerical simulations are carried out on the Eulerian problem by using a splitting method called Fast Dual Proximal Gradient method for which the convergence of the iterations is guaranteed by Beck and Teboulle in 2014. The regularity results allows us to show the existence of a Nash equilibrium.

Weak-Strong Uniqueness for Second-Order Mean-Field Games

Schedule: July 9 8:00-8:30 Room 825

Bashayer Majrashi

KAUST, Saudi Arabia

Co-Author(s): Rita Ferreira, Diogo A. Gomes, Bashayer H. Majrashi

Abstract:

We extend the weak--strong uniqueness principle for mean-field game (MFG) systems to a broad class of second-order stationary and time-dependent problems. Under standard monotonicity, growth, and coercivity assumptions on the Hamiltonian and relying strictly on the integrability exponents guaranteed by the existing theory for monotone MFG systems, we show that any weak solution must coincide with a given strong solution. Our analysis covers models with spatially dependent scalar diffusion coefficients, using monotonicity arguments and a coefficient-adapted mollification strategy to manage the variable diffusion terms. We extend this strategy to establish weak--strong uniqueness in the corresponding second-order, initial--terminal, time-dependent setting. Finally, to address the critical quadratic growth regime, we derive a new a priori second-order estimate for a stationary MFG system with logarithmic coupling, quantifying the control of second spatial derivatives of u weighted by m and of Dm in terms of the data and thereby establishing weak--strong uniqueness in this setting. Our results provide a unified framework for uniqueness and regularity in a wide array of MFG models.

Numerical approximation of first-order time-dependent, non-separable mean field games under displacement monotonicity

Schedule: July 8 9:30-10:00 Room 825

Yohance Osborne

Durham University, England

Co-Author(s): Alpar R Meszaros

Abstract:

In this talk, we introduce a numerical method to approximate first-order time-dependent mean field game (MFG) systems posed in $\mathbb{R}^d$ with non-separable, displacement monotone Hamiltonians and terminal costs, for arbitrary finite time-horizons and (possibly singular) initial player distributions with finite second moment. The numerical method is based on an implicit Euler discretization in time, together with sampling in space, of the characteristic Hamiltonian system associated with the continuous MFG system. We establish convergence of the scheme by proving an asymptotic error bound that implies optimal rates of convergence in the $L^\infty(L^2)$ -norm for the approximations as the number of spatial samples tends to infinity jointly with the temporal time-step vanishing. We conclude the talk with numerical experiments that illustrate the performance of the scheme for a range of time horizons.

A non-asymptotic approach to games with many players and the universality of the mean field game limit

Schedule: July 8 13:30-14:00 Room 825

Davide Francesco Redaelli

University of Rome Tor Vergata, Italy

Co-Author(s): Cirant M., Jackson J.

Abstract:

I will present a non-asymptotic approach to quantifying the gap between different notions of equilibrium in stochastic differential games with many players. Under suitable semi-monotonicity conditions, one can derive estimates for the Nash and Pontryagin systems that are uniform in the number of players. These estimates, in turn, yield quantitative convergence results for open-loop and closed-loop equilibria when interactions between players are weak. The results apply to games with interactions that are not necessarily symmetric and possibly much sparser than in classic mean field game theory, and they confirm the universality of the mean field game limit for games governed by sufficiently dense networks. Based on a joint work with Marco Cirant (Padua) and Joe Jackson (Chicago).

Ergodic Mean Field Games of Controls with State Constraints

Schedule: July 9 8:30-9:00 Room 825

Kyle Rosengartner

Baylor University, USA

Co-Author(s): Jameson Graber

Abstract:

In a mean field game of controls, players seek to minimize a cost that depends on the joint distribution of players' states and controls. We consider an ergodic problem for second-order mean field games of controls with state constraints, in which equilibria are characterized by solutions to a second-order MFGC system where the value function blows up at the boundary, the density of players vanishes at a commensurate rate, and the joint distribution of states and controls satisfies the appropriate fixed-point relation. We prove that such systems are well-posed in the case of monotone coupling and Hamiltonians with at most quadratic growth.

Fully nonlinear mean field games with nondifferentiable Hamiltonians

Schedule: July 8 8:00-8:30 Room 825

Iain Smears

University College London, England

Co-Author(s): Thomas Sales

Abstract:

We analyse fully nonlinear second-order mean field games (MFG) with nondifferentiable Hamiltonians, which take the form of a coupled system of a fully nonlinear Hamilton--Jacobi--Bellman equation and a Kolmogorov--Fokker--Planck partial differential inclusion (PDI) featuring the set-valued subdifferential of the Hamiltonian. We show the existence of solutions of some stationary MFG systems with quite general coupling operators and nonnegative distributional source terms, on general bounded convex domains, under the primary assumptions of uniform ellipticity and the Cordes condition on the diffusion coefficient. The existence proof is founded on an original, and equivalent, reformulation of the PDI as a nonstandard variational inequality (VI), that offers significant flexibility in passages to the limit. Furthermore, the uniqueness of the solution of the PDI/VI system is proved in the case of strictly monotone couplings. We then show how the MFG PDI/VI system in the fully nonlinear setting can be obtained as the limit of a sequence of PDE systems with differentiable Hamiltonians.

Solving First-Order Time-Dependent Mean-Field Games via Monotone Operator Theory

Schedule: July 8 8:30-9:00 Room 825

Melih Ucer

KAUST, Turkey

Co-Author(s): Diogo Gomes

Abstract:

We study first-order, local, time-dependent mean-field games on the torus with a monotone Hamiltonian, using a variational inequality principle developed by Ferreira, Gomes, et al. (2018, 2019, 2021). We prove two main results. First, we establish the existence of a solution to the variational inequality via monotone operator theory in Banach spaces. Second, we show that any such solution satisfying natural integrability conditions is a weak solution in the sense introduced by Cardaliaguet (2015) for separable mean-field games. Together, these results establish the variational inequality principle as a general framework for mean-field games with non-separable Hamiltonians, well beyond the scope of minimization-based methods, yet recovering the same solution concept that those methods yield in the separable case.

A quantitative limit theory for quadratic mean-field controls

Schedule: July 8 14:00-14:30 Room 825

Songbo S Wang

Université Côte d'Azur, France

Co-Author(s): Songbo Wang

Abstract:

Using an entropic formulation of the mean-field optimal control problem, we recast its convergence problem as the classical limit of mean-field Gibbs measures. This framework yields optimal convergence rates under path-dependent interactions and establishes sharp propagation of chaos estimates.

Mean-Field Games in Hilbert Spaces with Degenerate Noise: A Viscosity Approach

Schedule: July 9 9:00-9:30 Room 825

Lukas Wessels

Université Côte d'Azur, France

Co-Author(s): Andrzej Swiech

Abstract:

We investigate a Mean-Field Game (MFG) posed in an infinite-dimensional Hilbert space and driven by degenerate noise. The associated MFG system consists of a Hamilton--Jacobi--Bellman (HJB) equation for the value function coupled with a nonlinear Fokker--Planck (FP) equation for the distribution of the particles, both governed by a degenerate Kolmogorov operator. The degeneracy of the noise introduces significant analytical challenges. In particular, the HJB equation is treated in the viscosity sense, while the FP equation is interpreted in a suitable weak formulation. A major difficulty stems from the degeneracy of the Kolmogorov operator, which makes the uniqueness of solutions to the FP equation particularly delicate. Under appropriate structural assumptions, we establish well-posedness of the MFG system. As an application, we consider Mean-Field Games arising from stochastic delay differential equations, highlighting how delay effects naturally lead to infinite-dimensional and degenerate dynamics. This talk is based on joint work with Andrzej Świąch.

Long-Time Behavior of Mean Field Game Systems with Common White Noise

Schedule: July 8 17:00-17:30 Room 825

Wenbin YAN

University Paris Dauphine-PSL, France

Co-Author(s): Pierre Cardaliaguet, Wenbin Yan, Raphael Maillet

Abstract:

We study the long-time behavior of mean field game (MFG) systems driven by common noise, providing a natural yet unexplored extension of the deterministic MFG theory. In the deterministic setting, classical results establish convergence toward stationary solutions under suitable monotonicity assumptions. The presence of common stochastic perturbations, however, makes the analysis substantially more delicate. We consider a standard MFG model with infinitely many players whose dynamics are affected by both idiosyncratic and common noise, and we investigate its asymptotic behavior as the time horizon tends to infinity. Using quantitative arguments that replace the compactness methods available in the deterministic framework, we prove exponential convergence of the solutions toward a stationary regime. More precisely, we identify a deterministic ergodic constant and show the existence of stationary random processes describing the limiting behavior. We also establish almost sure long-time convergence through a detailed analysis of the ergodic master equation, which governs the asymptotic behavior of the master equation.

Special Session 185 : Multiscale Analysis: Geometry and Evolution Problems (mSPACE)

Organizer(s): Delio Mugnolo , Leonard Monsaingeon , Matthias Neumann

Introduction: Multiscale systems, where complex dynamics emerge from interactions across multiple spatial and temporal scales, are ubiquitous in nature, technology, and society. The recently approved COST Action mSPACE (CA24122) aims to establish a rigorous mathematical framework for the analysis of such systems, with particular emphasis on large-scale and long-time behavior in discrete, continuous, and hybrid models. By combining geometric and stochastic perspectives, mSPACE addresses fundamental challenges arising in linear and nonlinear models, network transport phenomena, and biological systems. Core mathematical tools include discrete calculus, asymptotic analysis, spectral geometry, gradient flows, and optimal transport. A prominent application area is materials science, where multiscale modeling and microstructure optimization naturally arise, illustrating how abstract theory can inform practical design. More broadly, mSPACE seeks to bridge fundamental analysis with real-world modeling challenges. This special session will showcase recent advances connected to the themes of the Action, bringing together theoretical developments, modeling approaches, and applications, and aims to foster interaction between the multiscale analysis community and applied researchers.

Eigenbranches of elliptic operators in singularly perturbed problems

Schedule: July 10 10:30-11:00 Room 311

Laura Abatangelo

Politecnico di Milano, Italy

Abstract:

We consider eigenproblems for elliptic operators in bounded domains, namely the Dirichlet Laplacian. Suppose to perturb the problem in one of the following ways: removing a small hole from the interior of the domain, attaching a thin tube at a boundary point, disrupting the Dirichlet boundary condition with a Neumann condition in a small part of the boundary. In all these cases the operator's spectrum is stable and eigenvalues can be continued as the perturbation parameter tends to zero. We can prove the sharp asymptotic behavior of eigenbranches which will strongly rely on the local behavior of the limit eigenfunctions at the perturbation point.

On open book analogs of quantum graphs

Schedule: July 9 13:30-14:00 Room 311

Setenay Akduman

Izmir Democracy University, Turkey

Co-Author(s): none

Abstract:

Quantum graphs have long served as effective models for thin structures. In various applications, however, such as photonic crystals and dynamical systems, one encounters stratified structures that naturally motivate higher-dimensional analogs of graph-like models. This leads to the study of “open book” type geometries, where multiple smooth “pages” meet transversely along a common “binding”. Such structures can be viewed as higher-dimensional stratified varieties equipped with differential operators. This talk develops a mathematical framework for quantum open books and defines the associated differential operators. After introducing metric open book structures, we formulate natural junction conditions and identify a subclass of gluing data that ensures the Fredholm property under suitable ellipticity assumptions. We also determine conditions guaranteeing self-adjointness of the corresponding operator, in relation to well-known results from quantum graph theory. From a broader perspective, these structures provide a multiscale modeling framework, in which lower-dimensional singular sets may appear as geometric interfaces between higher-dimensional components. This viewpoint connects the analysis of quantum open books with current developments in multiscale systems, particularly in settings where geometric, spectral, and analytic features interact across different dimensions. We also discuss several directions for future research.

On the Lumpability of Dynamical Systems

Schedule: July 10 9:00-9:30 Room 311

Fatihcan M. Atay

Bilkent University, Turkey

Co-Author(s): Fatihcan M. Atay

Abstract:

Multiscale systems often exhibit distinct yet related dynamical characteristics across different scales. One approach to exploring the relationship between dynamics at various spatial scales is through the concept of lumpability. This talk deals with exact lumpability of dynamical systems, namely the possibility of projecting the dynamics onto a smaller state space in which a self-contained dynamical description exists. This projection is also referred to as lumping, aggregation, or reduction in different contexts. We consider systems whose evolution is governed by bounded or unbounded linear operators on Banach spaces and derive conditions for lumpability in the language of semigroup theory. We further extend these results to nonlinear systems on finite-dimensional manifolds. Finally, we discuss lumpability within the framework of networks.

limits of time-changed degenerate semigroups & applications

Schedule: July 10 11:00-11:30 Room 311

Ali BenAmor

University of Sousse, high school for transport and logistics, Tunisia

Abstract:

For a given standard process and a sequence of measures converging vaguely to a final measure, under some assumptions, we establish convergence of the sequence of the semigroups and the resolvents of the corresponding time changed-processes. Some applications are given: convergence of solutions of evolution equations and convergence of finite time distributions, as well as weak convergence of the related processes.

on the p -Wasserstein barycenter: behaviours and regularity properties

Schedule: July 9 9:30-10:00 Room 311

Camilla Brizzi

Technical University of Munich (TUM), Germany

Co-Author(s): Gero Friesecke, Tobias Ried, Lorenzo Portinale

Abstract:

The talk is about the barycenters of N probability measures with respect to the p -Wasserstein metric ($p > 1$), which generalizes the notion of Wasserstein barycenters for $p = 2$, introduced by Agueh and Carlier. Providing a natural way to interpolate probability measures and computing a representative summary of input datasets, they are useful tools in data science, statistics, and image processing. This is a highly nonlinear problem but it can be rewritten as an equivalent multi-marginal optimal transport problem, paying with a (a priori) high dimension. Here we show that thanks to a new technique based on the geometric properties of the support of the optimal plan, the p -Wasserstein barycenters of absolutely continuous marginals are unique and absolutely continuous. This implies that the optimal MMOT plan is unique and can be parametrized as a graph over any marginal space (with a consequent dimension reduction). Some finer integrability properties of the density of the barycenter are also discussed. We present also some examples in one dimension, with emphasis on the statistical meaning of the p -Wasserstein barycenters and on the two natural limits $p \rightarrow 1$ and $p \rightarrow \infty$. This is based on joint works with G. Friesecke and T. Ried and L. Portinale.

Bi-Continuous semigroups for flows on infinite networks

Schedule: July 10 11:30-12:00 Room 311

Christian Budde

University of the Free State, So Africa

Co-Author(s): Marjeta Kramar Fijavz

Abstract:

In this talk we investigate transport processes on infinite metric graphs with non-constant velocities and matrix boundary conditions in the $\mathcal{L}^\infty$ -setting. We apply the theory of bi-continuous operator semigroups to obtain well-posedness of the problem under different assumptions on the velocities and for general stochastic matrices appearing in the boundary conditions. This is joint work with Marjeta Kramar Fijavz (Ljubljana, Slovenia).

Concentration phenomena of self-attention dynamics

Schedule: July 9 14:00-14:30 Room 311

Leon Bungert

University of Wuerzburg, Germany

Co-Author(s): Albert Alcalde, Konstantin Riedl, Tim Roith

Abstract:

In this talk I will speak about concentration phenomena of self-attention transformers in the regimes of infinitely many layers and tokens. The dynamics are described by the Fokker--Planck equation $\partial_t \rho_t^\beta(x) = -\operatorname{div}(\rho_t^\beta(x) P_x V_{\beta}[\rho_t^\beta](x))$, $\rho_t^\beta \in [0, T] \times \mathbb{S}^{d-1}$, where $\mathbb{S}^{d-1} := \{x \in \mathbb{R}^d, |x|=1\}$ is the sphere in $\mathbb{R}^d$, $T > 0$ is a time horizon, $P_x: \mathbb{R}^d \rightarrow \mathbb{R}^d$, $y \mapsto y - \langle x, y \rangle x$ is the projection onto $\mathbb{S}^{d-1}$, and $V_{\beta}[\rho_t^\beta](x) := \frac{\int_{\mathbb{S}^{d-1}} e^{\beta \langle x, y \rangle} \rho_t^\beta(y) dy}{\int_{\mathbb{S}^{d-1}} e^{\beta \langle x, y \rangle} dy}$, ρ_t^β involves the inverse heat parameter $\beta > 0$. The matrices $V, B \in \mathbb{R}^{d \times d}$ contain learned parameters and are assumed to be constant in time. It is known that for $\beta \rightarrow \infty$ solutions of the Fokker--Planck equation converge to solutions of a linear PDE, the solutions of which concentrate as $T \rightarrow \infty$ on the dominating eigendirections of the matrix B^{top} . In our work we will quantify these results by exploiting a striking similarity between self-attention dynamics and the so-called polarized consensus-based optimization (CBO) method for global optimization. Using a CBO-inspired analysis we give explicit bounds for the Wasserstein-2 distance of the solution of the Fokker--Planck equation and a suitable target measure. The proof relies on an application of a quantitative Laplace principle to $\partial_t \rho_t^\beta$ as well as a Lyapunov-type analysis for the time asymptotics. Our result sheds more light on the interior dynamics of self-attention transformers and might help identify reduced effective models.

Non-uniqueness of normalized ground states for nonlinear Schrödinger equations

Schedule: July 9 16:30-17:00 Room 311

Simone Dovetta

Politecnico di Torino, Italy

Abstract:

The talk discusses general non-uniqueness results for normalized ground states of nonlinear Schrödinger equations with power nonlinearity. Basically, we show that, when in the L^2 -subcritical regime ground states exist at every mass, for nonlinearity powers close to the L^2 -critical exponent there is at least one value of the mass for which ground states are non-unique. As a consequence, whenever such non-uniqueness occurs there exist action ground states that are not normalized ground states. These results have been obtained both when the problem is set on metric graphs (compact and non-compact) and when it is posed on polygons with homogeneous Neumann boundary conditions.

Graph approximation for nonlocal interaction equations

Schedule: July 9 14:30-15:00 Room 311

Antonio Esposito

University of L'Aquila, Italy

Abstract:

In this talk I will discuss the connection between nonlocal dynamics on graphs and the corresponding local counterparts in the underlying Euclidean space. Equations on graphs have been recently introduced in applications to data science and social dynamics, among others. Starting from the nonlocal interaction equation on graphs, we can obtain a class of nonlocal interaction equations with the presence of tensor-mobility encoding the information on the localised graph. This talk is based on joint works with G. Heinze, F. Patachini, A. Schlichting, and D. Slepcev.

On the stability of the JKO operator under different notions of convexity.

Schedule: July 9 17:00-17:30 Room 311

Sara Farinelli

University of Genova, Italy

Co-Author(s): Di Marino, Naldi

Abstract:

Given a metric space (X, d) and a functional $\mathcal{F}$ defined on it, a relevant role in the theory of gradient flows associated with $\mathcal{F}$ is played by the proximity operator
$$P_{\mathcal{F}}(x) \coloneqq \mathop{\arg\min}_y \left\{ \frac{1}{2} d^2(x, y) + \mathcal{F}(y) \right\}.$$
 In the setting of the Wasserstein space, that is $(X, d) = (P_2(\mathbb{R}^d), W_2)$, the proximity operator is often called JKO operator. Motivated from the fact that if (X, d) is a Hilbert space then $x \mapsto P_{\mathcal{F}}(x)$ is non-expansive when $\mathcal{F}$ is convex, the non-expansivity of the JKO operator has been a topic of investigation. It has been proved recently by Cavagnari-Savare-Sodini that if $\mathcal{F}$ is totally convex then non-expansivity holds. Various partial results are present in literature assuming weaker notions of convexity. In this talk we review these contributions and we present some generalizations under the assumption that $\mathcal{F}$ is convex on generalized geodesics. This is based on a joint work in preparation with Di Marino and Naldi.

Critical lack of detailed balance in stochastic kinetic proofreading models

Schedule: July 8 16:30-17:00 Room 311

Eugenia Franco

University of Bonn, Germany

Co-Author(s): J.J.L. Velázquez

Abstract:

In this talk, I will discuss the role of the lack of detailed balance in a class of stochastic kinetic proofreading models. Kinetic proofreading systems were proposed by Hopfield and Ninio in the 70s in order to explain the way in which receptors can distinguish between different ligands with a low error rate. This ability is referred to as specificity. It was already suggested by Hopfield that in order to achieve high specificity, the system must spend energy, hence it should not satisfy the detailed balance property. We prove the existence of a critical amount of lack of detailed balance that kinetic proofreading models must have in order to have strong specificity.

Effective transmission through a thin heterogeneous layer via EDP-convergence

Schedule: July 9 17:30-18:00 Room 311

Gianna Goetzmann

University of Augsburg, Germany

Co-Author(s): Lucas M. Fix, Malte A. Peter, Jan-F. Pietschmann

Abstract:

We study the asymptotic behavior of a Fokker--Planck system in a domain consisting of two bulk regions connected by periodically arranged channels within a thin heterogeneous layer. Both the layer thickness and the distance between the channels scale with $\varepsilon \ll 1$. The system admits a gradient flow formulation with respect to the Boltzmann entropy functional defined on the space of probability measures. Using the notion of EDP-convergence, which is based on the energy--dissipation principle, we aim to derive an effective transmission model in the limit $\varepsilon \rightarrow 0$.

On the asymptotic behavior of the spectral gap for discrete Schrödinger operators

Schedule: July 10 12:00-12:30 Room 311

Matthias Hofmann

FernUniversität in Hagen, Germany

Co-Author(s): Joachim Kerner, Maximilian Pechmann

Abstract:

We investigate the asymptotic behavior of the spectral gap of a class of discrete Schrödinger operators defined on a path graph in the limit of infinite volume. We confirmed recent results and generalized them to a larger class of potentials using entirely different methods. Notably, we also resolved a conjecture previously proposed in this context, which yields new insights into the rate at which the spectral gap tends to zero as the volume increases. This is joint work with Joachim Kerner (FernUniversität in Hagen) and Maximilian Pechmann (Tennessee Technology University).

The dynamic Schrödinger problem on metric graphs

Schedule: July 10 13:30-14:00 Room 311

Juliane Krautz

University of Augsburg, Germany

Co-Author(s): Jan-F. Pietschmann

Abstract:

We study the dynamic formulation of the Schrödinger problem on metric graphs. Using the direct method of calculus of variations, we show existence of minimizers and investigate the connection to dynamic optimal transport. A particular focus lies on the analysis of Γ -convergence between both problems for vanishing diffusive effects.

Asymptotic Analysis of a Biharmonic Steklov Problem on Thin Domains

Schedule: July 8 17:30-18:00 Room 311

Pier Domenico Lamberti

University of Padova, Italy

Co-Author(s): Bauyrzhan Derbissaly

Abstract:

We analyze the asymptotic behavior of eigenvalues and eigenfunctions for a biharmonic Steklov problem on a thin domain in $\mathbb{R}^n$ collapsing to a segment. In dimension $n=2$, the model describes vibrations of a thin elastic plate with mass concentrated on part of the boundary. The problem depends on a parameter σ , representing the Poisson ratio, which plays a key role in the limiting process. As the thickness vanishes, we derive the limit problem and show that the resulting operator exhibits a nontrivial distortion depending on both σ and the space dimension n . Based on a joint work with Bauyrzhan Derbissaly.

Fractal Inverse Problems: The Crucial Role of Scaling

Schedule: July 8 17:00-17:30 Room 311

Maria Rosaria Lancia

Sapienza Università di Roma, Italy

Co-Author(s): Simone Creo, Gianluca Mola, Silvia Romanelli

Abstract:

This paper investigates the well-posedness and approximation of inverse problems formulated on highly irregular spatial domains, including those with fractal boundaries. The primary objective is the identification of a constant diffusivity parameter, $\alpha_* > 0$, within an abstract parabolic Cauchy problem. This identification relies on a quadratic overdetermining condition, which requires measuring the L^2 -norm of the solution's energy at a fixed measuring time-instant $T > 0$. To address the geometric complexities inherent to irregular domains, we introduce a sequence of approximating direct and inverse problems defined on smoother, more regular spatial domains. The rigorous convergence of these approximations to the exact solution of the original inverse problem is established through the Mosco convergence of the associated Dirichlet energy forms. Crucially, appropriate scaling is fundamental in proving this Mosco convergence of the energies, precisely because there is a jump of dimension when passing from the regular approximating domains to the highly irregular or fractal limit geometry. Finally, we will also address the case of a fractional-in-time inverse problem, demonstrating the versatility of the proposed mathematical framework.

Probing the influence of topological and geometric disorder on the spectrum of the differential Laplacian operator on networks

Schedule: July 9 18:00-18:30 Room 311

Jeremy L Marzuola

University of North Carolina, USA

Co-Author(s): Charles Maher and Katherine Newhall

Abstract:

Metric networks are network-shaped, one-dimensional structures on which one can solve differential equations to simulate a wide range of physical systems including conjugated molecules, photonic crystals, quantum mechanics in waveguide networks, and acoustic metamaterials. More concretely, a metric network is a network whose edges are each assigned a notion of length and a coordinate describing position. One can then define function spaces and differential operators on these objects to model the aforementioned systems. Recent software advancements have made it feasible to analyze partial differential equations on large, compact metric networks with a vast array of structures. Here, we generate compact metric network structures using the spatial tessellations of two-dimensional hyperuniform point patterns, which have suppressed large-scale density fluctuations relative to typical disordered point patterns. This choice of structure is inspired by the exotic physical properties of network materials with these structures in other contexts. Then, we characterize the eigenvalue spectrum structure of the differential Laplace operator on these networks. In particular, we find that gaps can form in the eigenvalue spectra of these networks whose widths increase when the distribution of edge lengths is narrow and as the number of triangular faces increases. Importantly, many of the structures we consider are realizable in Euclidean space, meaning they are well-suited for practical applications in, e.g., metamaterial design. This work can thus be used to inform the design of metric network-based systems with spectral gaps with tunable widths and locations.

Multiscale approaches in optimal control

Schedule: July 9 18:30-19:00 Room 311

Idriss Mazari-Fouquer

CEREMADE, Paris Dauphine University PSL, France

Abstract:

We report on recent progress in using oscillatory techniques to derive point wise and geometric properties in optimal control theory, in particular to derive the bang-bang property in parabolic models.

Quantitative converge for displacement monotone Mean Field Games of controls

Schedule: July 9 15:00-15:30 Room 311

Alpar R Meszaros

Durham University, England

Abstract:

In this talk we present some recent results about quantitative convergence of Nash equilibria (both open and closed loop) of a general class of N-player stochastic differential games, when agents interact through the empirical measure supported on both states and controls. Our analysis is based on a careful comparison between open and closed loop Nash equilibria, and the mean field Nash equilibrium. A particular challenge is to understand the properties of an additional fixed point map and to obtain dimension-free estimates as N increases to infinity. Our quantitative analysis does not impose implicit assumptions on the fixed point map nor uses the master equation, but it relies on displacement monotonicity techniques. The talk will be based on joint works with Joe Jackson (University of Chicago).

Replicator dynamics as the large population limit of a discrete Moran process

Schedule: July 10 9:30-10:00 Room 311

Marco Morandotti

Politecnico di Torino, Italy

Co-Author(s): Gianluca Orlando

Abstract:

The replicator dynamics accomplishes the task of modelling the evolution of strategies in a population by subjecting the probability of reproduction to their fitness: The higher the fitness, the higher the chance of being selected to reproduce. Yet, the criterion followed by individual agents to select their strategies is latent in the replicator equation, which describes the continuous-time evolution of the proportions of strategies in an averaged fashion. In this talk, we provide a mathematical framework to derive the replicator equation as a mean-field limit of a discrete stochastic process modelling this evolutionary mechanism from the point of view of individual agents and their pairwise interactions. In this context, the classical Moran process is a prototypical example of discrete stochastic process that models natural selection in finite populations with two strategies (alleles, in biology) competing for dominance. We study the mean-field limit of a generalised Moran process as the number of agents diverges and we show that, in the weak selection regime, it converges to the replicator dynamics.

Regularity by duality for minimising movements with nonlinear mobility

Schedule: July 9 8:30-9:00 Room 311

Lorenzo Portinale

Universita' di Milano statale, Italy

Co-Author(s): Emanuela Radici, Simone di Marino

Abstract:

In this talk, we discuss conservation laws that can be written as gradient flows with respect to a Wasserstein distance with nonlinear mobility. In particular, we discuss ideas for inferring regularity estimates for time-discretisation schemes using two important tools: (dynamical) duality and comparison principles.

Westervelt Boundary Value Problems on Domains With Non-Lipschitz Boundaries

Schedule: July 9 15:30-16:00 Room 311

Anna Rozanova-Pierrat

CentraleSup'elec, University Paris-Saclay, France

Co-Author(s): A. Dekkers, M.Hinz, A. Teplyaev

Abstract:

We obtain the global on-time well-posedness of the Robin type boundary valued problem for the Westervelt equation on a bounded domain with a non-Lipschitz boundary. The obtained weak solutions are considered in the domain of Laplacian and thus are more regular than H^1 . The irregularity of the boundary does not allow the usual H^2 -regularity. In the framework of uniform domains in $\mathbb{R}^2$ or $\mathbb{R}^3$ we also validate the approximation of the solution of the Westervelt equation on a fractal domain by the solutions on the prefractals using the Mosco convergence of the corresponding variational forms. We consider the shape optimization problem for this ultrasound wave propagation model to minimize the system's total acoustic energy by the shape of the boundary for fixed source and initial data. For the Robin boundary, modeling the reflection, we prove the existence of an optimal shape realizing the infimum of the acoustic energy in a class of Lipschitz boundaries. Using its relaxation on the uniform class of domains, we prove the existence of an optimal shape realizing the minimum.

Spectral Flow and Eigenvalue Comparison for Schrodinger Operators on Metric Graphs

Schedule: July 10 14:00-14:30 Room 311

Gilad Sofer

Technion - Israel Institute of Technology, Israel

Co-Author(s): Ram Band, Marina Prokhorova

Abstract:

When comparing the spectra of two self-adjoint operators, it is often useful to compare their eigenvalue counting functions. A well-known result in this direction for Schrodinger operators on metric graphs is known as Dirichlet-Neumann bracketing, which essentially states that the eigenvalue counting functions of the Dirichlet and Neumann Laplacians differ by at most the size of the boundary. This can be seen as a manifestation of how local boundary conditions influence global spectral quantities. The goal of this talk is to introduce a useful tool for such comparison results, known as the spectral flow, which is a topological invariant associated with one-parameter families of self-adjoint operators. In this setting, the parameter can be interpreted as a continuous change of boundary conditions or coupling along the graph. We show that for Schrodinger operators on metric graphs, the spectral flow can be effectively computed using the associated scattering matrices. We then present several applications, in the form of generalized nodal index theorems and eigenvalue interlacing results, which quantify how spectral data evolves under these changes. The talk is based on joint work with Ram Band and Marina Prokhorova.

Censored subordinate Brownian motion

Schedule: July 9 9:00-9:30 Room 311

Vanja Wagner

University of Zagreb, Croatia

Abstract:

Let $D \subset \mathbb{R}^d$, be an open d -set, and L a nonlocal operator of the form $L = -\phi(-\Delta)$, where $\phi: (0, \infty) \rightarrow (0, \infty)$ is a complete Bernstein function. The operator L is a generator for the subordinate Brownian motion, with the Laplace exponent ϕ of the subordinator, and admits the following singular integral form
$$Lu(x) = \int_{\mathbb{R}^d} (u(y) - u(x)) j(|y-x|) dy, \quad u \in C_c^2(\mathbb{R}^d),$$
 where $j: (0, \infty) \rightarrow (0, \infty)$ is the corresponding radially decreasing Lévy density. In this talk, we revisit the regional subordinate Laplacian on D , i.e. the nonlocal operator of the form
$$L_D u(x) = \int_D (u(y) - u(x)) j(|y-x|) dy, \quad u \in C_c^2(D),$$
 and two associated strong Markov processes on $\overline{D}$ -- the censored and resurrected subordinate Brownian motions on D . Specifically, we discuss the pathwise behaviour of these processes and give conditions under which they are equivalent.

Panarchy: From Theory to Measurement

Schedule: July 10 8:30-9:00 Room 311

Hannah HZ Zoller

Stockholm Resilience Centre, Sweden

Abstract:

Multiscale analysis is a key aspect of complexity science. An established conceptual framework grounded in resilience science is provided by L. H. Gunderson's and C. S. Holling's *Panarchy* heuristic (2002), which envisions a complex system as a nested set of cyclic processes, hierarchically structured across spatiotemporal scales. Originally formulated for socio-ecological systems, this model has been rapidly adopted across scientific disciplines, including biology, economics, and politics. However, to date, corresponding studies have been almost exclusively of qualitative nature. An integral quantitative approach to panarchies would require the identification of relevant operating scales, the assessment of adaptive cycles within scales, and the estimation of information flow across scales. Current quantitative approaches cover only individual aspects, leveraging established measures rooted in spectral analysis, information theory, and network analysis (Angeler et al. 2023). In this talk, we review the recent development and consider potential future pathways.

Special Session 186 : Recent Advances in Symbolic Computation and Applications

Organizer(s): Zafeirakis Zafeirakopoulos , Ioannis Emiris , Ilias Kotsireas

Introduction: Symbolic Computation has a long history of developing algorithmic tools used throughout a variety of fields of mathematics, sciences and engineering. The use of exact tools in an inexact world sounds often counterintuitive, but found numerous applications in the last decades. The development of algebraic algorithms and their applications lead this effort. In this session, we discuss interactions between concepts and tools from symbolic computation and the theory and applications in other areas of mathematics and the sciences. In particular, we welcome contributions on algorithmic and computational aspects of tools and theory in the intersection of computer science and mathematics.

Computable oneway functions on the reals

Schedule: July 10 15:00-15:30 Room 638

Georgios Barmpalias

Institute of Software, Chinese Academy of Sciences, Peoples Rep of China

Abstract:

Central in computational complexity and cryptography is the notion of oneway functions: finite maps that are easy to compute but hard to invert. Levin recently extended this concept to functions on the reals - infinite bit-sequences - using computability and algorithmic randomness. He asked whether computable oneway real functions exist, and whether they can satisfy properties that are desirable in cryptography, such as collision-resistance. In this talk I will present answers to some of these questions and additional results on probabilistic hardness of inversion for real functions. I will then proceed to explore variations of this concept and focus on characterizing the unsolvability of inverting effective real functions. I will conclude with several open questions and connections between this and several topics in computability and algorithmic randomness. This is joint work with Mingyang Wang and Xiaoyan Zhang based on the preprints: <http://arxiv.org/abs/2406.15817> <http://arxiv.org/abs/2501.02604> <https://arxiv.org/abs/2412.07592>

Vertically parametrized systems, matroids and positive solutions

Schedule: July 10 12:00-12:30 Room 638

Carles Checa

University of Copenhagen, Denmark

Co-Author(s): Elisenda Feliu

Abstract:

We study vertically parametrized polynomial systems, a class of parametrized systems arising in contexts such as chemical reaction network theory. We establish an effective criterion for determining whether an augmented vertical system admits multiple positive zeros for some choice of parameter values. The criterion reduces this question to checking the feasibility of a linear system of equalities and inequalities, providing a sufficient condition for the absence of multiple positive zeros that applies to any augmented vertical system. When the kernel of the coefficient matrix displays a certain sparsity structure, this condition becomes also necessary. In this talk, I will show their connection with the criterion for positive real solutions, as well as related features involving matroids and root counts over the complex torus.

Learnability of Algorithms

Schedule: July 10 11:00-11:30 Room 638

Kimion Fountoulakis

Computer Science, University of Waterloo, Canada

Abstract:

This talk examines when and how machine learning models can learn to execute algorithms. Such reasoning underpins core tasks such as arithmetic and sorting, which are often used as testbeds for algorithmic reasoning. I present both lower and upper bound results. On the negative side, I show that end-to-end training can be inefficient for learning algorithms, while step-by-step supervision enables efficient learnability. On the positive side, I demonstrate that neural networks can be trained to execute algorithms and general computer instructions exactly. Finally, I quantify their ensemble complexity, which provides a lower bound on the number of independent training runs required to achieve zero error. These results indicate when algorithmic behavior is learnable in practice and when structural barriers make it provably hard.

E*-Groebner Bases via Homogenization and Applications to Bivariate Difference Dimension Polynomials

Schedule: July 10 11:30-12:00 Room 638

Alexander Levin

Catholic University of America, USA

Abstract:

We present a homogeneous Groebner theoretic framework for E*-Groebner bases in difference modules and applications to bivariate difference dimension polynomials. The approach uses graded homogenization in which the homogenizing variable z is taken to be the greatest variable. With this choice homogeneous leading terms encode affine coleaders and homogeneous reduction dehomogenizes naturally to E*-reduction. This yields a Buchberger type algorithm for E*-Groebner bases via homogenization and saturation placing effective order methods into a standard Groebner basis framework. Using these bases we construct bivariate difference dimension polynomials for finitely generated difference modules and difference field extensions. While the classical univariate dimension polynomial measures total order growth the bivariate polynomial describes how growth is distributed across order windows. We prove that certain coefficients are generator independent invariants refining the classical theory. These invariants distinguish nonisomorphic difference modules and detect nonequivalence of systems sharing identical invariants of univariate dimension polynomials.

Groebner bases, Grassmannians, and Low-Rank Matrix Completion

Schedule: July 10 13:30-14:00 Room 638

Manolis Tsakiris

Chinese Academy of Sciences, Peoples Rep of China

Abstract:

Low-rank matrix completion is an interdisciplinary problem across statistics, machine learning and signal processing, in which the objective is to complete a partially observed $m \times n$ matrix of typically small rank r . A fundamental question is which observation patterns admit finitely many completions of rank r , and among them, which ones admit a unique completion. This can be recast as a problem in algebraic geometry, where one aims to determine whether a system of polynomial equations with coefficients rational functions in the observed entries has finitely many solutions (or even a unique solution). We will report families of finitely and uniquely completable patterns for any matrix size and any rank, which we have obtained by 1) interpreting low-rank matrix completion as a linear section problem on the Grassmannian and 2) using families of local coordinates on the Grassmannian that Sturmfels & Zelevinsky described in 1993.

Condition-based Low-Degree Approximation of Real Polynomial Systems. I: The Zero-Dimensional Case

Schedule: July 10 14:30-15:00 Room 638

Elias Tsigaridas

Inria Paris and Sorbonne University, France

Co-Author(s): Josue Tonelli-Cueto

Abstract:

We provide new bounds on the number of real zeros of a (zero-dimensional) polynomial system in terms of the condition number of the system. In the probabilistic setting, this translates into new estimates on all the moments of the number of the real zeros of random polynomial systems, including Kac and KSS polynomial systems. Moreover, the provided bounds are robust: they do not require the Gaussian assumption.

Integer multiplication is at least as hard as matrix transposition

Schedule: July 10 10:30-11:00 Room 638

Joris van der Hoeven

CNRS, Ecole polytechnique, France

Abstract:

Working in the multitape Turing model, we show how to reduce the problem of matrix transposition to the problem of integer multiplication. If transposing an $n \times n$ binary matrix requires $\Omega(n^2 \log n)$ steps on a Turing machine, then our reduction implies that multiplying n -bit integers requires $\Omega(n \log n)$ steps. In other words, if matrix transposition is as hard as expected, then integer multiplication is also as hard as expected.

ReLU and Softplus neural nets as zero-sum, turn-based, stopping games

Schedule: July 10 14:00-14:30 Room 638

Ioannis Vlassopoulos

Athena Research Center, Greece

Co-Author(s): Stephane Gaubert

Abstract:

Neural networks are generally treated as black boxes. In an effort to uncover the mathematical structure underlying them, we explain how ReLU nets can be interpreted as zero-sum turn-based, stopping games. The game runs in the opposite direction to the net and running the net is the same thing as running the Shapley- Bellman backwards recursion for the value of the game. Net weights are used to define state transition probabilities and the biases define rewards. The input to the net is the terminal reward of the game, the output of any neuron is the value of the game at a corresponding game state. We will explain applications of this construction, among which is the calculation of interval bounds for the output of every neuron given interval bounds for the input to the net. Another is the interpretation of a ReLU net classifier as a game between 2 players, one of which is trying to prove the input is in a given class and the other trying to prove the opposite. Adding an entropic regularization to the ReLU net game allows us to interpret Softplus nets as games analogously. This is joint work with Stéphane Gaubert.

Special Session 187 : New Trends in Crowd Dynamics and Traffic Flow

Organizer(s): Nouredine igbida , Karami Fahd , El Mahdi Erraji

Introduction: This session focuses on recent advances in the mathematical modeling, analysis, and numerical treatment of crowd and traffic dynamics, ranging from single-population models to multi-population systems with complex interactions. Topics include continuum models based on transport and nonlinear diffusion equations, second-order and congestion-aware formulations, and variational approaches such as gradient flows, minimizing movement schemes, and generalized minimal-flow principles. Particular attention will be given to the incorporation of physical and geometric constraints, including density saturation, capacity limits, obstacles, and anisotropic or directed motion. From an analytical perspective, contributions addressing existence, stability, and qualitative properties of solutions, as well as the interplay between Eulerian and Lagrangian descriptions, are especially welcome. Extensions to multi-population settings—capturing segregation, competition for space, and heterogeneous behaviors—will also be highlighted, together with their associated mathematical challenges. Overall, the session aims to provide a coherent overview of current mathematical developments in the study of collective motion and mobility systems, bridging modeling, analysis, and applications.

Congested Crossing Pedestrian Traffic Flow : Dispersion vs. Transport in Crowded Areas

Schedule: July 10 14:30-15:00 Room 637

Mariam AL KHATIB

University of Limoges, France

Abstract:

This study investigates the dynamic interactions between two populations coexisting within a shared spatial domain. We develop theoretical and numerical approaches to analyze situations in which one population must traverse a territory occupied by another, requiring strategies to mitigate congestion due to spatial limitations. Population 1 is modeled through a linear transport equation, while Population 2 is described by a granular diffusion model inspired by sandpile dynamics, capturing its internal reorganization and natural tendency to decongest. Numerical simulations are used to explore how different movement strategies adopted by the traversing population—such as directed motion toward a target, internal spreading to reduce local density, or uniform dispersion across the domain—influence the response and redistribution of the resident population. The results highlight how the interplay between transport and granular diffusion mechanisms shapes the global behavior of the system.

Error Estimate for a Semi-Lagrangian Scheme for a Time-Dependent Hamilton-Jacobi Equation on Networks

Schedule: July 10 11:30-12:00 Room 637

Elisabetta Carlini

Sapienza University of Rome, Italy

Abstract:

We study the numerical approximation of time-dependent Hamilton-Jacobi equations on networks. In particular, we introduce a semi-Lagrangian scheme and prove a convergence error estimate of order $1/2$. The analysis relies on showing the equivalence between two notions of solutions proposed by Imbert and Monneau (2017) and Siconolfi (2022). Numerical simulations illustrating the performance of the scheme are also presented.

Deterministic Mean Field Games with jumps

Schedule: July 10 13:30-14:00 Room 637

Annette Dumas

Université de Limoges, XLIM, France

Co-Author(s): Filippo Santambrogio

Abstract:

The Mean Field Game we consider is motivated by the modelization of the housing dynamics where each inhabitant can move from one place to another. In particular, the trajectories of the agents are piecewise constant and they minimize a cost consisting in the number of jumps (or relocations) and two terms depending on the density: the first one is variational and the other one is non-variational. A Nash equilibrium for this mean field game is a measure over the curves minimizing a problem in a Lagrangian form which depends on the measure itself. To prove the existence of a Nash equilibrium, we reformulate the problem, thanks to an optimal transport result, in a Eulerian form for which we prove regularity results. The Eulerian formulation also allows us to perform numerical simulations thanks to a Fast Dual Proximal Gradient method for which the convergence of the iterations is guaranteed by Beck and Teboulle (2014). We will see that the mixed structure with the non-variational term in the problem enables us to consider more complex cost functions and also examples with two populations.

On a modified Hughes model for crowd motion

Schedule: July 10 8:30-9:00 Room 637

Hamza Ennaji

Univ. Grenoble Alpes, CNRS, Grenoble INP*, LJK, France

Co-Author(s): Nouredine Igbida, Jos\`{e} Miguel Urbano

Abstract:

We introduce a macroscopic crowd motion model inspired by Hughes (2002, 2003), coupling a nonlinear conservation law for pedestrian density with an Eikonal equation characterizing the shortest path. This approach modifies Hughes' original formulation and refines the prediction-correction framework recently proposed by Ennaji, Igbida and Jradi (2023). By incorporating anticipatory behavior and dynamic route adjustment, our model offers a realistic representation of crowd dynamics in complex environments. Finally, we present the mathematical formulation, discuss its well-posedness, and illustrate its qualitative behavior through numerical simulations.

A New Class of Non-Linear PDEs for Species Dispersal under Congestion Constraints

Schedule: July 10 8:00-8:30 Room 637

Nouredine igbida

Unniveristy of Limoges, France

Abstract:

This talk introduces a new class of cross-diffusion systems designed to study the dispersal of species under overcrowding constraints. Moving beyond classical W_2 -Wasserstein flows or standard PDE couplings, we propose an approach based on proximal energy minimization through a minimum flow process. This framework allows us to establish a well-posed PDE system that captures the delicate interplay between diffusion and concentration gradients. Specifically, for homogeneous cases, we derive a well-defined PDE grounded in a novel H^{-1} -theory specifically developed for overcrowding dispersal.

Fully discrete follow-the-leader approximation of one-dimensional scalar conservation laws with vacuum

Schedule: July 10 9:30-10:00 Room 637

Valeria Iorio

University of L'Aquila, Italy

Abstract:

We present a fully discrete particle approximation for one-dimensional scalar conservation laws. Under suitable monotonicity assumptions on the macroscopic velocity, we construct a vacuum-compatible family of time-discrete particle equations and show that an appropriate piecewise-constant density reconstruction from the particle setting converges to the unique entropy weak solution of the macroscopic scalar conservation law. This is a joint work with Marco Di Francesco, Simone Fagioli, and Massimiliano Daniele Rosini.

Analysis of some pedestrians PDE models for a population under stress

Schedule: July 10 9:00-9:30 Room 637

Kamal Khalil

LMAH, University of Le Havre Normandie, FR-CNRS-3335, ISCN, Le Havre 76600, France., France

Abstract:

In this talk, we investigate several macroscopic PDE models for pedestrian dynamics describing the spatio-temporal evolution of a population under stress (panic) in dangerous situations. We first present a first-order model for the evacuation of a stressed population from a room with an exit, incorporating different interacting human behaviors. For this model, we establish the local existence, uniqueness, and regularity of solutions using semigroup theory, together with their positivity and (L^1) -boundedness. To illustrate the propagation of stress (panic) and its impact on evacuation dynamics, we provide numerical simulations of several evacuation scenarios, with particular emphasis on populations with a low-risk culture in emergency situations. We then introduce a second-order model to better capture stress effects within the population and compare its dynamics with those of the first-order model.

Merging agent-based and Mean Field Game descriptions of crowd dynamics

Schedule: July 10 15:00-15:30 Room 637

Konstantinos Koutsomitis

Universite Paris Saclay/ LPTMS, France

Co-Author(s): Cécile Appert-Rolland, Denis Ullmo

Abstract:

Mean Field Games is a powerful tool to describe competitive optimization processes among agents. A natural field of application is crowd dynamics where pedestrians optimize their path, while interacting with the others. Due to the backward-forward structure of the MFG equations, anticipation is included in the model, which is often a key element to reproduce pedestrian behavior. In this formalism, the interactions among the agents are usually considered exclusively inside the minimization of a functional (personal cost), in the decision-making level and not in the operational, at the agent scale. This approach often fails to describe situations where the granular effects are dominant, namely while passing through a bottleneck. To enhance the realism of the framework, we aim to incorporate these granular effects by considering explicit microscopic interactions in the Mean Field Game derivation. In this direction, we treat a toy-model by replacing Langevin dynamics for the agents with a one-dimensional Exclusion Process, which is a paradigmatic model of interacting particles, especially in transport and congestion phenomena. We will show how to derive the corresponding Mean Field Game equations and discuss the effect of these interactions on the Nash equilibrium of the game, in particular in the case of evacuations. This study can be seen as a first step towards the study of other interacting models and their potential Mean Field Games counterparts.

Fully discrete methods for Wasserstein gradient flows and crowd motion

Schedule: July 10 10:30-11:00 Room 637

Filippo Santambrogio

Institut Camille Jordan, France

Co-Author(s): Anatole Gallouet, Anastasiia Hraivoronska

Abstract:

In 2010 we introduced, together with Maury and Roudneff-Chupin, a simple evolution model for crowd motion which happens to be a gradient flow in the Wasserstein space $\mathcal{W}_2$ of a potential energy with a density constraint. Recently, with Hraivoronska we proposed a full discretization of some Wasserstein gradient flows on a fixed grid and found the necessary and sufficient condition in terms of the time and space steps to obtain convergence. This method is particularly efficient in the case of the crowd motion gradient flow, as it only requires to solve a sequence of linear programming problems. In a joint ongoing work with A. Gallouet and Hraivoronska we exploit this in order to obtain efficient numerical simulations: I will present these results and all the strategies that we develop to reduce the corresponding computational cost.

Optimal Control of Sweeping Processes: Theoretical Framework and Numerical Approximation

Schedule: July 10 11:00-11:30 Room 637

Francisco Silva

XLIM, Université de Limoges, France

Co-Author(s): Justina Gianatti and Emilio Vilches

Abstract:

In this talk, based on joint work with J. Gianatti and E. Vilches, we first provide a theoretical framework for finite horizon optimal control problems in which the state is governed by a controlled sweeping process, and we show that the value function is the unique viscosity solution of the associated Hamilton-Jacobi-Bellman equation. We then introduce a semi-Lagrangian scheme to approximate the value function and establish its convergence. Finally, we present numerical experiments for two-dimensional problems and discuss some promising extensions.

From Mean Field Games to a Hughes-Type Model: A Lagrange-Galerkin Approach

Schedule: July 10 14:00-14:30 Room 637

Ahmad Zorkot

University of Vienna, Austria

Co-Author(s): Elisabetta Carlini and Francisco J. Silva

Abstract:

We present a numerical scheme for a Hughes-type model where agents optimize based only on the current population distribution $\rho_m(t)$. Unlike classical Mean Field Games where agents anticipate future crowd evolution, at each time step a new Hamilton-Jacobi-Bellman equation is solved with the instantaneous density. Our method combines a semi-Lagrangian discretization for the value function with a Lagrange-Galerkin approximation for the continuity equation. We prove well-posedness and convergence of the scheme. We also introduce a hybrid system coupling both MFG and Hughes-type populations. Various numerical tests are presented for both models, showing distinct behavioral patterns in congestion and target accumulation.

Special Session 188 : Dynamics of interacting optical solitons

Organizer(s): Omri Gat

Introduction: Dissipative optical solitons are highly localized nonlinear waveforms that arise as attractors of driven-dissipative propagation models. They are routinely generated in mode-locked lasers and Kerr microresonators, where they appear as ultrashort pulses that underpin a wide range of scientific and technological applications, including Nobel-Prize-winning advances in precision measurement, frequency metrology, and ultrafast science. In many experimentally relevant regimes, lasers and resonators support multiple coexisting solitons. When these solitons remain well separated, their individual profiles are only weakly perturbed, and their interactions are governed by a small set of global soliton degrees of freedom, such as timing and phase, which are associated with spontaneously broken continuous symmetries. Over the past decade, advances in real-time measurement techniques have enabled direct observation of this dynamics, revealing a striking diversity of phenomena, including soliton molecules and crystals, bifurcations, dynamical transitions between coherent and incoherent binding, synchronization, and chaos. While many of these effects are reproduced in numerical simulations, progress toward a unifying theoretical framework has been slow. The goal of this Special Session is to foster interaction between theory and experiment to identify the key concepts and methods that can facilitate the breakthrough needed for predictive control of complex multi-soliton states.

Nonlinear synchronisation and routes to complexity in breathing-soliton lasers

Schedule: July 7 17:30-18:00 Room 823

Sonia Boscolo

VPIphotonics GmbH & Aston Institute of Photonic Technologies, Germany

Co-Author(s): Junsong Peng, Xiuqi Wu, Huiyu Kang, Anran Zhou, Ying Zhang, Heping Zeng, Christophe Finot

Abstract:

We present an overview of our recent research demonstrating ultrafast fibre lasers operating in the breathing-soliton regime--dynamic pulses exhibiting periodic energy oscillations--as a powerful and versatile platform for investigating nonlinear synchronisation dynamics within a single oscillator. In these systems, synchronisation emerges intrinsically from nonlinear coupling between internal cavity frequencies, enabling self-synchronisation without external forcing. Leveraging advanced diagnostics and control strategies, we uncover a rich spectrum of dynamical behaviours, including higher-order Farey hierarchies of frequency-locked breather states, self-similar fractal structures (devil's staircases), abnormal synchronisation domains characterised by unconventional Arnold tongues, transitions between synchronised and desynchronised regimes--including a previously unknown intermediate dynamical state--and a new route to chaos arising from the breakdown of regular dynamics. A unified theoretical model, revealing distinct breather formation mechanisms under net-normal and near-zero cavity dispersion, explains the different experimental behaviours observed in these regimes in terms of pump-power accessibility relative to stationary mode locking, oscillation periods, spectral features, and synchronisation capabilities. Together, these findings advance the understanding of nonlinear dynamical systems and provide a novel experimental framework for probing and controlling complex dynamical regimes.

Laser soliton interactions through optoacoustic effects in photonic crystal fibers

Schedule: July 7 17:00-17:30 Room 823

Wenbin He

Shanghai Institute of Optics and Fine Mechanics, CAS, Peoples Rep of China

Co-Author(s): Wenbin He, Meng Pang, Xin Jiang, and Philip St.J. Russell

Abstract:

Solid-core photonic crystal fibers (PCF) can greatly enhance optoacoustic effects due to the tight confinement of both optical and acoustic modes. By leveraging the enhanced optoacoustic nonlinearity in a PCF in a mode-locked fiber laser, we have achieved the self-organization of a large number of laser solitons through long-range optoacoustic interactions mediated by coherently stimulated acoustic resonance, resulting in a highly ordered soliton sequence with prominent self-stability and flexibility. We investigated the self-organization dynamics of multi-soliton structures through a hierarchical study and simulated the process using a highly effective low-dimensional model based on coarsely grained dynamics. In addition to enabling a self-stabilizing, pattern-editable pulsed laser with a GHz repetition rate, this unique long-range interaction has also facilitated the generation of a new type of complex multi-scale soliton sequences, known as soliton supramolecules, through cooperative balancing with other interaction mechanisms. We have also realized a "parallel optical-soliton reactor" via controllable soliton interactions within a massive number of parallel temporal trapping potentials based on the optoacoustic effects, enabling statistical studies of laser soliton interactions.

Dissipative patterns, solitons and bullets under radiative effects, higher dimensions, and topology. Bifurcations and dynamics overview.

Schedule: July 7 13:30-14:00 Room 823

Carles Milian Enrique

Universitat Politècnica de Valencia, Spain

Co-Author(s): Carlos Mas, Salim Ivars, Pol Molina, Yaroslav Kartashov

Abstract:

Recent progress on the effects of higher dimensions, Raman scattering, and Cherenkov analogue radiation emitted by dissipative solitons in driven micro-cavity is presented, together and separately. Novel insights in the context of normal vs anomalous dispersion regimes are presented. We report on one-dimensional radiating solitons of the bright and dark natures in the anomalous and normal cavity dispersion regimes, aiming at elucidating certain previously seemingly unexplored connections amongst them. Additionally, we show that in higher dimensions, new types of nonlinear states appear under the action of a spatially localised driving fields. These include localised patterns and solitons of the quiescent and moving types. To finalise, we briefly show robust topological light-bullets in large area fiber loops co-living with the higher order and typically detrimental effects.

Localized patterns and slanted snaking in bichromatically driven pure Kerr optical cavities

Schedule: July 7 15:00-15:30 Room 823

Pedro Parra-Rivas

Universidad de Almeria, Spain

Co-Author(s): E. K. Akakpo, Y. Sun, M. Erkintalo, F. Leo, and P. Parra-Rivas

Abstract:

We investigate the bifurcation structure and stability of localized temporal patterns in bichromatically driven pure Kerr optical cavities. In contrast to the common case, where localized states are supported by a uniform background state, here localization occurs within a modulated background. By performing bifurcation analysis, we unveil the origin of such states and find that they undergo a slanted snake-and-ladder structure. These states endure oscillatory instabilities which lead to breathers: oscillatory localized patterns. In the presence of desynchronization between the envelope formed from the superposition of the driving fields and an integer fraction of the cavity round trip time, these states are asymmetric, stable, and drift at a constant speed. As a result, the slanted snaking breaks, leading to the formation of isolas. We find that, eventually, by increasing that parameter, these localized patterns disappear.

Two-photon dual-comb imaging of soliton dynamics

Schedule: July 7 16:30-17:00 Room 823

Lukasz A Sterczewski

Wroclaw Univeristy of Science and Technology, Poland

Abstract:

Optical solitary waves (solitons) arise from the balance between dispersion and nonlinear effects at high optical intensities in laser cavities. Interestingly, solitons can form transient or stable pulse aggregates referred to as soliton molecules. Although these structures show promise for applications in quantum memory and advanced telecommunications, they present challenges in laser development. Emission involving multiple pulses affects nonlinear frequency conversion and generates pronounced amounts noise. Moreover, detecting these formations is difficult with standard methods such as intensity autocorrelation or spectral analysis due to instrumental constraints, so they often go overlooked. In this talk, we will discuss a practical method for fast, real-time diagnostics of pulsed lasers based on two-photon absorption in a nonlinear photodetector. This approach allows the observation of soliton molecules with separations ranging from femtoseconds to nanoseconds, across any wavelength and timescale, using a standard telecom laser oscillator and a low-bandwidth oscilloscope. We will demonstrate how this technique can be used to monitor basic soliton molecules, such as triplets and quadruplets, as well as more intricate structures like molecular crystals and soliton rains. We will also cover the use of shared-cavity dual-comb lasers for studies on soliton-soliton interactions.

Pathway-Resolved Noise Channels in Temporal Cavity Solitons

Schedule: July 7 14:30-15:00 Room 823

Yifan Sun

Universite libre de Bruxelles, Belgium

Abstract:

Fluctuations of nonlinear coherent structures arise not only from direct stochastic forcing, but also from deterministic transfer among coupled collective coordinates. In this talk, I present a framework for resolving such noise pathways in a stable temporal cavity soliton governed by the generalized Lugiato-Lefever equation with Raman response. By projecting both the field dynamics and the vacuum noise onto four soliton coordinates: amplitude, frequency shift, temporal position, and global phase, we derive a reduced stochastic model whose linearization yields an analytic power-spectral-density matrix. This formulation separates direct noise injection from inter-coordinate transfer and thereby exposes the internal routing of fluctuations. It captures frequency-to-timing conversion associated with Gordon-Haus-type jitter, identifies amplitude-to-phase coupling as a major source of phase noise, and reveals Raman-enabled cascaded transfer pathways. It also explains the low-detuning enhancement of intensity and phase noise through an underdamped amplitude-phase relaxation mode that emerges before the onset of breathing. Comparisons with stochastic simulations of both the reduced model and the full equation show good agreement across most of the stable stationary regime.

Stairway to soliton in the down conversion regime

Schedule: July 7 14:00-14:30 Room 823

Francesco Rinaldo Talenti

University of Bath, England

Abstract:

Although a solitary wave is conventionally defined as being driven by third-order nonlinearities, recent theories and experiments have proposed novel approaches that extend functionalities and applications by exploiting other nonlinear terms. In particular, the generation of harmonics via $\chi(2)$ effects underpins two-color soliton generation. The physics increases in complexity and interest, as a plethora of novel stable solutions can be generated. Specifically, we show how a staircase of Eckhaus instabilities directly links the homogeneous steady state to the half-harmonic soliton in the down-converted regime. Interestingly, we found that the conversion between harmonics also facilitates dark soliton excitation at the driven wavelength, a phenomenon that is typically difficult to achieve in standard systems.

Special Session 189 : Analysis and applications of elliptic and parabolic equations

Organizer(s): Lihe Wang , Dongsheng Li , Congming Li

Introduction: This session is on the recent researches in the analysis and fine properties for elliptic and parabolic equations. Topics include, estimates, regularity and symmetric properties for solutions of elliptic and parabolic solutions to elliptic, parabolic equation from analysis, geometry, fluid dynamics and mathematical biology.

Partial Regularity for Navier-Stokes equations

Schedule: July 7 16:30-17:00 Room 826

Lihe Wang

University of Iowa, USA

Co-Author(s): Lihe Wang

Abstract:

We will present a new compactness lemma that can handle the noncompactness in the present and through which proves the partial regularity theorem.

Regularity for ω -minimizers of general p -Laplacian type functionals with matrix weights

Schedule: July 7 17:00-17:30 Room 826

Rui Yang

Central South University, Peoples Rep of China

Abstract:

We study general p -Laplacian type functionals with matrix weights, which may cause degeneracy, singularity, or both. We establish an optimal Calderon-Zygmund theory for any ω -minimizer of such weighted energy functionals under a smallness log-BMO condition on the matrix weight and quantitative control of ω -minimality, the weighted gradient enjoys the same integrability as the weighted nonhomogeneous term. This is joint work with Sun-sig Byun.

Mathematical analysis of a tumor invasion model

Schedule: July 7 17:30-18:00 Room 826

Shulin Zhou

Peking University, Peoples Rep of China

Abstract:

In this talk I will introduce a reaction-diffusion system modelling tumor invasion. The underlying partial differential equation system has cross-diffusion and density-dependent diffusion coefficient and involves the interactions of three quantities: tumor tissue density, acid concentration and normal tissue density. The most distinguished feature of this model is that the diffusion of tumor cells is influenced by the density of normal cells and diffusion degeneracy arises when normal cells are at their carrying capacity. Therefore, this system is strongly coupled and might be degenerate. I will review the known mathematical results of this system and present our new results of this system.

Special Session 190 : Amplitude equations for continuous, discrete, non-local, and stochastic nonlinear dispersive and dissipative dynamical systems

Organizer(s): Ioannis Giannoulis , Anna Logioti , Guido Schneider

Introduction: This special session brings together researchers considering problems related to deriving and justifying continuous dynamical systems, so called amplitude equations, that describe macroscopic features of dynamical systems evolving originally on a microscopic scale. A typical macroscopic feature could be the amplitude function of a slowly modulated rapidly oscillating carrier wave. The most prominent amplitude equations in this setup are the nonlinear Schrödinger equation, the Korteweg-de Vries equation, and the Ginzburg-Landau equation. In most cases the formal derivation of the macroscopic amplitude's evolution equation is straightforward, but its justification, proving the approximation's validity over the slow timescale of the amplitude equation's evolution, can be subtle depending on the setting. Indeed, there exist counterexamples which show that the validity of such modulation equations isn't automatically fulfilled upon their formal derivation. Recently, relevant new results have been obtained for conservation laws, degenerated systems, completely integrable systems, space-dependent systems, stochastic PDEs, lattice equations with stochastic coefficients, or non-local systems with fractional derivatives. It is the purpose of this special session to give a forum for the presentation of these new developments.

A dispersive relaxation mechanism: blow-up vs. stability in absence of any localization assumptions on initial data

Schedule: July 8 15:00-15:30 Room 628

Joannis Alexopoulos

Karlsruhe Institute of Technology, Germany

Abstract:

The study of long-time behavior in dispersive equations typically relies on energy estimates that require localization assumptions on initial data. In this talk, we explore large-time dynamics without imposing any such localization conditions. We discuss a variant of the Gross-Pitaevskii equation on the real line which is used to model superfluidity properties of Bose-Einstein condensates. This model can be viewed as intermediate between the classical Gross-Pitaevskii equation, by keeping leading order dispersion, and the complex Ginzburg-Landau equation, by adding typical balance terms. We identify a relaxation mechanism close to the wave functions $e^{i\omega t + ikx}$, which arises through the interaction between diffusive- and dispersive effects. This relaxation process allows to show nonlinear stability of the wave functions in C_b^k against perturbations from $C_b^{k+1+\sigma}$ for all $\sigma > 0$. In contrast, we also establish finite time blow-up solutions in C_b^k whenever we include initial C_b^{k+1} -perturbations: this shows that our stability result is sharp concerning global existence. To the best of our knowledge, this work provides a first analysis of long-time dynamics in dispersive models without any localization assumptions on initial data, and may motivate further research directions. Specifically, we expect that the blow-up vs. stability phenomenon also appears for the Lugiato-Lefever equation.

Validity of the Ginzburg-Landau Approximation for Pattern Forming Quasilinear Systems

Schedule: July 8 8:30-9:00 Room 628

Theo Belin

Lund University, Sweden

Co-Author(s): Guido Schneider

Abstract:

We present a method justifying that the Ginzburg-Landau equation is a valid modulation equation for a wide class of quasilinear dissipative systems. The modulation equation can be derived near the first instability of a Turing or Turing-Hopf bifurcation of spatially homogeneous steady states and correctly predicts the behavior of the solution on the long timescale. The proof of the approximation result relies on maximal regularity and a fixed point argument that can be expressed in a rather abstract way. This allows, for instance, to validate the modulation equation for initially nonlocalized perturbations. We show that the arguments can be applied to the quasilinear Klausmeier-Gray-Scott system as well as a quasilinear version of the Bénard-Rayleigh convection model.

Heterogeneities in reaction-diffusion systems: A feature, not a perturbation

Schedule: July 8 14:00-14:30 Room 628

Martina Chirilus-Bruckner

Leiden University, Netherlands

Co-Author(s): Jolien Kamphuis, Lara van Vianen, Frits Veerman

Abstract:

Spatial heterogeneities are often treated as an inconvenience: they break translation invariance, complicate spectral analysis, and blur bifurcation scenarios familiar from homogeneous media. In this talk, we argue that heterogeneity is not just a complication, but also a useful tool for generating, selecting, and stabilizing coherent structures. We develop an analytical framework for existence, stability, and bifurcations in reaction-diffusion systems with spatially dependent coefficients, focusing on front and wave train dynamics. The presentation is centered around two case studies. First, we examine heterogeneous front solutions in a FitzHugh-Nagumo equation, where spatial variability produces fronts that propagate at non-constant speeds through stationary heterogeneous background states. Second, we study wave trains governed by a Ginzburg-Landau amplitude equation arising as slow modulations in a Swift-Hohenberg model, showing how spatially non-uniform coefficients affect wave-number selection. A common thread is the use of perturbation techniques involving a small parameter. Importantly, this parameter does not measure the size of the spatial heterogeneity. Instead, it reflects scale separation or nearness to a critical regime, allowing order-one heterogeneities while preserving analytical tractability. The key novelty is extending classical perturbative approaches to include non-autonomous terms systematically. This yields solvability conditions and reduced modulation equations in spatially varying environments naturally.

Modulation equations for scalar Fermi-Pasta-Ulam-Tsingou systems on 2D square lattices

Schedule: July 8 17:30-18:00 Room 628

Ioannis Giannoulis

University of Ioannina, Greece

Co-Author(s): Bernd Schmidt, Guido Schneider

Abstract:

We present results concerning the justification of modulation equations for the dynamics of atoms in a two-dimensional square lattice that interact with their nearest neighbors nonlinearly with respect to the strain between their scalar displacements. When the interaction forces are cubic we show that small macroscopically modulated amplitudes of rapidly oscillating plane waves evolve approximately according to a nonlinear Schroedinger equation, while in the case of quadratic interaction forces the corresponding modulation equation is a Davey-Stewartson system. Due to the dispersive scaling of the small amplitudes, the justification in the latter case is significantly more involved than in the former and necessitates the employment of normal-form transformation techniques.

Amplitude Equations for Nonlocal Swift-Hohenberg Equation

Schedule: July 8 8:00-8:30 Room 628

Christian Kuehn

TUM, Germany

Abstract:

In this talk I am going to present various results regarding the derivation of amplitude equations for nonlocal PDEs. In particular, we shall consider nonlocal reaction terms as well as nonlocal fractional diffusion in the context of the Swift-Hohenberg equation. Interestingly, the resulting Ginzburg-Landau-type amplitude equations become fully local with the non-local influence only entering to leading-order in the coefficients. This shows an interesting decoupling effect near instability. I shall explain, how this effect arises in the proofs as well. The work is based upon the following papers: (1) Validity of amplitude equations for nonlocal nonlinearities, C. Kuehn and S. Throm, Journal of Mathematical Physics, Vol. 59, 071510, 2018. (2) The amplitude equation for the space-fractional Swift-Hohenberg equation, C. Kuehn and S. Throm, Physica D, Vol. 472, 134531, 2025.

Validity of the stochastic Ginzburg-Landau approximation in higher space dimensions -- A Wiener algebra approach --

Schedule: July 8 9:00-9:30 Room 628

Anna Logioti

University of Stuttgart, Germany

Co-Author(s): Guido Schneider

Abstract:

We consider an anisotropic d -dimensional Swift-Hohenberg model $\mathcal{O}(\varepsilon^2)$ -close to the first instability, where $0 < \varepsilon \ll 1$ is a small perturbation parameter. This model for pattern formation is perturbed with additive noise in time and space. By a multiple scaling ansatz we derive a stochastic d -dimensional Ginzburg-Landau equation for the approximate description of the bifurcating solutions. We prove the validity of the approximation by this amplitude equation on its natural time scale in case of d -dimensional periodic domains of length $\mathcal{O}(1/\varepsilon)$ for the Swift-Hohenberg model under suitable conditions on the additive noise. In detail, we prove the validity of this approximation for noise whose set of Fourier coefficients with respect to x is in ℓ^1 for fixed $t \geq 0$. Moreover, we improve existing approximation results in the sense that the stable part of the noise can be larger.

Bifurcation of cylindrical solutions in the spontaneous curvature model

Schedule: July 8 9:30-10:00 Room 628

Alexander Meiners

University of Oldenburg, Germany

Abstract:

We consider the L^2 gradient flow of the Helfrich model for lipid bilayers. The model incorporates constraints on membrane inextensibility (area constraint) and the absence of osmotic exchange (volume constraint). These constraints give rise to Lagrange multipliers, which appear as non-local terms. The lipid bilayer serves as a simplified model for the shape of red blood cells as well as other self-organizing cellular structures in biology. We studied bifurcation of closed vesicles using pde2path. We extend this to cylindrical topology. Well-known phenomena are the pearling instability of the cylindrical shape and transitions to coiled structures solution. We find them and other bifurcations using center manifold analysis and numerical continuation. Due to the presence of Lagrange multipliers, we take a non-standard approach to derive amplitude equations for each bifurcation scenario. Within this framework, we analyze the stability of the bifurcation branches. To provide a broader perspective on the shape transitions of cylindrical structures, we employ numerical continuation, similar to our approach for closed vesicles. However the analysis shows some discrepancies with experiments.

On the closeness of the dynamics for some nonlinear lattices

Schedule: July 8 13:30-14:00 Room 628

Simone Paleari

Università di Milano, Italy

Co-Author(s): Tiziano Penati, Marco Calabrese

Abstract:

We study the closeness between the Ablowitz-Ladik, Salerno, and discrete nonlinear Schrödinger lattices in regimes of small coupling ϵ and small energy norm ρ . Two approaches are compared: direct estimates in physical variables and a transformation to canonical symplectic coordinates via Darboux variables.

Time-Periodic Dynamics in Driven-Damped ϕ^4 Models: From Reduced Chaos to PDE-Level Existence Theory

Schedule: July 8 14:30-15:00 Room 628

VASSILIOS M ROTHOS

Aristotle University of Thessaloniki, Greece

Co-Author(s): Vassilis Rothos

Abstract:

We study time-dependent dynamics in driven-damped ϕ^4 models with spatial and spatiotemporal modulations, focusing on the connection between reduced dynamical descriptions and rigorous PDE-level analysis. Collective-coordinate reductions reveal complex behavior, including separatrix splitting and chaotic kink motion under periodic forcing. However, the existence of time-periodic solutions at the level of the full PDE remains largely open. We address this by proving the existence of time-periodic solutions for a driven-damped ϕ^4 equation on a bounded domain with periodic boundary conditions. The analysis is based on a Lyapunov-Schmidt reduction in a time-periodic Hilbert space. A key feature is that damping ensures uniform invertibility of the linearized operator, eliminating the need for non-resonance conditions typical of conservative systems. Our results provide a rigorous PDE-level counterpart to time-periodic responses observed in reduced models and numerical studies.

The NLS approximation for the Peregrine soliton and fractional dispersion

Schedule: July 8 16:30-17:00 Room 628

Nils Thorin

Universität Stuttgart, Germany

Co-Author(s): Guido Schneider, Anna Logioti, Theo Belin

Abstract:

In this talk I am going to cover various topics regarding the validation of the NLS approximation in dispersive systems. In the first half of the talk we will study a family of solutions to the NLS called the Peregrine Soliton family, which are not covered by previously known approximation theory, as they do not approach zero for $|x| \rightarrow \infty$. Either the envelope spatially decays to zero over a temporally oscillating background, or it is fully spatially periodic, and special care is necessary when it comes to choice of function spaces to work in. The second half of the talk will instead focus on the NLS approximation in the presence of a fractional Laplacian. Still, a fully local NLS can be derived from the original, non-local system. The fact that the approximation is strongly localized around the wave number k_0 is used to, in lowest order, be able to use similar methods as in the regular case. Something of note is that the character of the derived NLS (focusing/defocusing) may change depending on choice of basic wave number, which is a stark difference to the classic case. This talk is based on joint work with Guido Schneider, Anna Logioti and Theo Belin.

Long-wave KdV hierarchy approximation of the NLS hierarchy with nonzero boundary condition

Schedule: July 8 15:30-16:00 Room 628

Robert Wegner

Karlsruhe Institute of Technology, Germany

Abstract:

The nonlinear Schrödinger and Korteweg--De Vries equations are both universal amplitude equations for one-dimensional nonlinear dispersive waves. As a consequence of their complete integrability, they both have an associated infinite hierarchy of nonlinear PDEs: the NLS and KdV hierarchies. We present an approximation of certain renormalized conserved quantities for the NLS hierarchy with nonzero boundary condition, in the long-wave regime, by the energies of the KdV hierarchy. We use this to prove that long-wave solutions to the NLS hierarchy with nonzero boundary condition are approximated by two solutions to KdV hierarchies on a certain timescale.

A variational reduction for the full-dispersion Davey--Stewartson equation

Schedule: July 8 17:00-17:30 Room 628

Espen Xylander

Institute for analysis, dynamics and modeling, University of Stuttgart, Germany

Abstract:

In this talk, we discuss a method to derive the classical Davey--Stewartson equation from its full-dispersion counterpart. After a brief tour of the relevant parameter regimes, we prove an approximation result for the energy functionals associated with the equations, based on a Lyapunov--Schmidt-type reduction. We then touch upon some existence results.

Special Session 191 : Stochastic Dynamical Systems Under Levy Noise: Theory and Applications

Organizer(s): Ting Gao , Xiaoli Chen

Introduction: This session aims to explore the rich mathematical structure and diverse applications of stochastic dynamical systems driven by Lévy noise. Moving beyond classical Gaussian perturbations, Lévy processes provide a crucial framework for modeling systems with discontinuous paths and heavy-tailed fluctuations, offering greater realism in numerous fields. We invite contributions addressing both foundational theory and cutting-edge applications. Key topics include, but are not limited to: the mean field limit theory for interacting particles; geometric stochastic dynamics in Stochastic Contact & Hamiltonian Systems; connections to non-equilibrium thermodynamic and statistical mechanics; the analysis of path probabilities via the Onsager-Machlup action functional; and novel applications in learning dynamics and the characterization of noise-induced transitions. This session will foster dialogue on how Lévy noise fundamentally alters dynamical behavior, bridging pure mathematics with applied physics, engineering, and data science.

Critical Transitions in Multi-Particle Systems: A Generative Control Framework via Onsager Machlup Functionals

Schedule: July 9 8:00-8:30 Room 824

Jianyu Chen

Nanyang Technological University, Singapore

Co-Author(s): Jianyu Chen, Ting Gao, Jinqiao Duan

Abstract:

This paper studies the most probable transition paths of high dimensional stochastic interacting particle systems and their mean field limits. Since these paths are difficult to compute directly, we reformulate the problem as a mean field optimal control problem based on the Onsager Machlup action functional. Using the stochastic Pontryagin maximum principle, we prove existence and uniqueness of the solution and derive a coupled system for the control variables. We also show that the Hamiltonian extremum conditions are equivalent to the conditions from the Pontryagin maximum principle. This equivalence gives an indirect characterization of the most probable transition paths and shows their correspondence with the paths of the mean field limit system.

How Mathematical Structures Emerge from Uncertainties: Dynamics, Geometry, and Topology

Schedule: July 9 8:30-9:00 Room 824

Ting Gao

Huazhong University of Science and Technology, Peoples Rep of China

Abstract:

Uncertainty is inherent in data generation processes, whether arising from stochastic dynamics, limited samples, or complex multi-scale interactions. Understanding how structured patterns emerge from such uncertainties is a central challenge in generative modeling. This report explores this question through the lens of dynamics, geometry, and topology, with a particular focus on early warning prediction. We investigate the mechanisms underlying critical transitions in generative models, including mode collapse and vector field splitting, which manifest as topological changes across scales. We introduce entropy-based indicators defined in the space of probability measures to assess and anticipate such transitions.

A kernel method for the learning of Wasserstein geometric flows

Schedule: July 9 9:00-9:30 Room 824

Jianyu Hu

Nanyang Technological University, Singapore

Abstract:

In this talk, we address the inverse problem of simultaneously recovering free energy defined on the density manifold from discretized observations of the density flow, which generated by Wasserstein gradient or Hamiltonian flow. We formulate the problem as an optimization task that minimizes a loss function specifically designed to enforce the underlying variational structure of Wasserstein flows, ensuring consistency with the geometric properties of the density manifold. Our framework employs a kernel-based operator approach using the associated Reproducing Kernel Hilbert Space (RKHS), which provides a closed-form representation of the unknown components. Furthermore, a comprehensive error analysis is conducted, providing convergence rates under adaptive regularization parameters as the temporal and spatial discretization mesh sizes tend to zero. Finally, a stability analysis is presented to bridge the gap between discrete trajectory data and continuous-time flow dynamics for the Wasserstein Hamiltonian flow.

Nonlocal Kramers-Moyal formulas and data-driven discovery of stochastic dynamical systems with multiplicative Levy noise

Schedule: July 9 13:30-14:00 Room 824

Yang Li

Nanjing University of Science and Technology, Peoples Rep of China

Co-Author(s): Jinqiao Duan

Abstract:

Traditional data-driven methods, effective for deterministic systems or stochastic differential equations (SDEs) with Gaussian noise, fail to handle the discontinuous sample paths and heavy-tailed fluctuations characteristic of Lévy processes, particularly when the noise is state-dependent. To bridge this gap, we establish nonlocal Kramers-Moyal formulas, rigorously generalizing the classical Kramers-Moyal relations to SDEs with multiplicative Lévy noise. These formulas provide a direct link between short-time transition probability densities (or sample path statistics) and the underlying SDE coefficients: the drift vector, diffusion matrix, Lévy jump measure kernel, and Lévy noise intensity functions. Leveraging these theoretical foundations, we develop novel data-driven algorithms capable of simultaneously identifying all governing components from data and establish convergence results and error analysis for the algorithms. We validate the framework through extensive numerical experiments on prototypical systems. This work provides a principled and practical toolbox for discovering interpretable SDE models governing complex systems influenced by discontinuous, heavy-tailed, state-dependent fluctuations, with broad applicability in climate science, neuroscience, epidemiology, finance, and biological physics.

Learning Stochastic Dynamical Systems via An Energetic Variational Approach

Schedule: July 9 14:00-14:30 Room 824

Yubin Lu

South China University of Technology, Peoples Rep of China

Abstract:

In this talk, I will present our recent work on learning stochastic dynamical systems through an energetic variational approach, and discuss its connections with existing methods. I will then present a series of numerical experiments to demonstrate the effectiveness and robustness of the proposed framework, particularly in the presence of noisy and partial observations.

Local and Global Solutions for Stochastic Transport-Type Equations with Nonlocal Noise

Schedule: July 9 14:30-15:00 Room 824

Yingting Miao

Xi'an Jiaotong-Liverpool University, Peoples Rep of China

Abstract:

This presentation discusses results on stochastic transport-type equations driven by genuinely mixed multiplicative noise. The noise comprises a continuous component (interpreted in both the Stratonovich and Itô senses) and a discontinuous component (interpreted in the Marcus sense). The Stratonovich and Marcus noise amplitudes are given by (nonlocal) pseudo-differential operators, which include the classical transport operator as a special case. Within this setting, we establish the existence, uniqueness, and a blow-up criterion for pathwise classical solutions. We further prove that sufficiently fast-growing noise ensures global regularity.

Anomalous branching processes: probabilistic behavior and connection to nonlinear time-fractional PDEs

Schedule: July 9 15:00-15:30 Room 824

Nicolas Privault

Nanyang Technological University, Singapore

Co-Author(s): Gerardo Perez-Suarez and Nicolas Privault

Abstract:

We present a class of non-Markovian branching processes, called anomalous branching processes, and study their probabilistic properties, such as the behavior of the moments of the number of particles alive at a time t on a given set. Those processes are then used to derive a probabilistic representation for the solutions of time-fractional F-KPP equations. By exploiting this connection, we also derive estimates for the probability tail of the position of the rightmost particle in the one-dimensional case.

Levy noise versus Gaussian-noise-induced transitions in the Ghil-Sellers energy balance model

Schedule: July 9 18:00-18:30 Room 824

Larissa Serdukova

University of Leicester, Department of Computing and Mathematical Science, England

Co-Author(s): Valerio Lucarini, University of Leicester, UK. Georgios Margazoglou, Moody's Corporation, UK

Abstract:

We investigate the effects of stochastic forcing on the Ghil-Sellers energy balance climate model by introducing fluctuations in solar irradiance. Using numerical simulations, we analyse noise-induced transitions between coexisting warm and snowball climate states. We consider multiplicative stochastic forcing driven by Gaussian noise and α -stable Lévy noise with $\alpha \in (0, 2)$, focusing on the statistics of transition times and the structure of the most probable transition paths. While Gaussian noise-induced transitions in metastable systems are well understood and serve here as a reference case, much less is known about the corresponding behaviour under Lévy noise, particularly in high- or infinite-dimensional systems. In the weak-noise regime, we find fundamentally different scaling laws for residence times in metastable states. For Gaussian noise, the classical Kramers-type exponential scaling is recovered, whereas Lévy noise leads to power-law scaling with exponent $-\alpha$, consistent with rigorous results for related systems with additive Lévy forcing. This behaviour can be interpreted by modelling the Lévy noise as a compound Poisson process. We also examine transition paths in a reduced state-space projection. Gaussian-driven transitions pass through the same unstable edge state, while Lévy-driven transitions follow distinct paths through the closest basin boundary to the originating attractor.

Identifying and Predicting Critical Transitions in a Cdc2-Cyclin B/Weel System

Schedule: July 9 16:30-17:00 Room 824

Hui Wang

Zhengzhou University, Peoples Rep of China

Abstract:

Critical transitions in intracellular regulatory networks, driven by fluctuations in protein concentrations, are fundamental to cellular decision-making and disease-related state transition. We investigate the stochastic dynamics of the Cdc2-Cyclin B/Wee1 regulatory module under Gaussian noise, focusing on how variations in feedback strength modulate system stability and transition behavior. By analyzing time-series data of protein concentrations, we evaluate a set of statistical, informational, and dynamical indicators to identify early signatures of critical transitions. Feature selection techniques are employed to determine the most informative indicators, which are subsequently incorporated into a deep learning framework based on a multilayer perceptron (MLP) regression model to predict the future evolution of Cdc2-Cyclin B concentrations and provide early warning of impending transitions.

Modeling Epidemic Dynamics: A Stochastic SIR Framework with Tempered Stable Distributions

Schedule: July 9 17:00-17:30 Room 824

YUNFEI XIA

Harbin Engineering University, Peoples Rep of China

Co-Author(s): Yang Jia; Ling Xue

Abstract:

We study a stochastic SIR model driven by multivariate tempered stable (TS) to capture heavy-tailed, cross-compartment shocks. The noise has a tail index $\alpha \in (0,1)$ with exponential tempering, accommodating rare, large jumps while preserving finite second moments and flexible dependence. Within a spectral-radial specification, finite spectral measure on the unit sphere coupled with a prescribed radial density, we characterize the infinite Lévy measure and the resulting dynamics. We establish a sharp threshold separating extinction from persistence: below the threshold, the epidemic dies out; above it, the process admits a unique ergodic stationary distribution. Monte Carlo experiments reproduce jump-triggered flare-ups and abrupt regime shifts. Overall, our results show that epidemic persistence is governed not only by variance, but critically by tail shape and the magnitude of large jumps, underscoring the relevance of TS noise for data with sudden outbreaks and correlated shocks.

Convergence of One--Dimensional Ising--Kac--Kawasaki Dynamics to Stochastic Cahn--Hilliard Equations

Schedule: July 9 17:30-18:00 Room 824

Qi Zhang

Beijing Institute of Mathematical Sciences and Applications, Peoples Rep of China

Abstract:

In this talk, we consider the scaling limit of the one-dimensional lattice Ising--Kac--Kawasaki dynamics under conservative Kawasaki exchange rate. For the Kac coarse-grained field (X_γ) , we derive a martingale formulation with a discrete conservative drift and a Dynkin martingale. The nonlinear drift is identified by a conservative multiscale replacement scheme based on one-block/two-block estimates, yielding a cubic conservative term in the macroscopic equation. For the stochastic part, we compute the predictable quadratic variation, and obtain a divergence-form Gaussian noise. As a consequence, (X_γ) converges to a one-dimensional stochastic Cahn--Hilliard equation with conserved noise.

Special Session 192 : Numerical methods for complex differential equation models

Organizer(s): Yu Feng , Liu Liu , Yanli Wang

Introduction: Differential equation models play a fundamental role in describing complex phenomena in the natural sciences, engineering, and socio-economic systems. These models are often characterized by strong nonlinearities, multiscale interactions, high dimensionality, and limited or noisy data, which pose significant challenges for numerical computation. This session focuses on recent advances in numerical methods for complex differential equation models, with an emphasis on robust, efficient, and reliable computational techniques. Topics include classical numerical methods for ordinary and partial differential equations, such as finite difference, finite element, and time integration methods, as well as modern approaches for stiff, multiscale, and high-dimensional systems. The session also welcomes contributions on hybrid and data-assisted numerical methods, including physics-informed and structure-aware machine learning approaches, which aim to enhance traditional numerical frameworks while respecting underlying mathematical and physical constraints. Particular attention will be paid to stability, accuracy, and structure preservation in challenging modeling settings.

A LAX-WENDROFF TYPE THEOREM OF DOUBLY CONSERVATIVE SCHEMES FOR DEGENERATE CONVECTION-DIFFUSION EQUATIONS

Schedule: July 9 8:00-8:30 Room 826

Juan Cheng

Capital Normal University, Peoples Rep of China

Abstract:

It is well known that a numerical scheme for solving a hyperbolic conservation law, when convergent, may not always converge to a weak solution. The remedy is the famous Lax-Wendroff theorem, stating that a conservative numerical scheme, when convergent, always converges to a weak solution of the conservation law. In this talk, we address the same issue for numerically solving degenerate nonlinear diffusion or convection-diffusion equations. We start with an example showing that a conservative scheme, in the sense of that for conservation laws, may still converge to a function which is not a weak solution of the degenerate nonlinear diffusion equation. We then introduce a stronger form of conservative schemes, which we term as doubly-conservative (DoC) schemes, that would allow the proof of a Lax-Wendroff type theorem, namely if a DoC scheme converges, then it will converge to the weak solution of the degenerate nonlinear diffusion or convectiondiffusion equation. Finally, we design a new DoC local discontinuous Galerkin scheme that remains semi-discrete stable even when the diffusion coefficient degenerates. Numerical experiments demonstrate optimal convergence rates of this new scheme and validate our theoretical results.

Data-driven Discovery of Asymmetric Interacting Particle Systems

Schedule: July 9 9:30-10:00 Room 826

Jinchao Feng

Great Bay University, Peoples Rep of China

Co-Author(s): Sui Tang

Abstract:

Interacting particle systems provide a powerful modeling framework for collective dynamics in nature and engineering. While prior methods have primarily addressed symmetric interactions using various learning techniques, many real-world systems exhibit asymmetric interactions, which demand more general and flexible modeling tools. In this talk, I will present a new Sparse Bayesian Learning (SBL) framework for identifying asymmetric interaction kernels in the Motsch-Tadmor model. By reformulating the nonlinear inverse problem as a subspace identification task, we establish identifiability guarantees and enable robust kernel recovery. Incorporating informative priors, the proposed SBL algorithm offers principled model selection and uncertainty quantification, achieving reliable inference from noisy trajectory data.

A Stabilized Numerical Framework for Necrotic Tumor Growth via Coupled Boundary Integral and Obstacle Solvers

Schedule: July 9 9:00-9:30 Room 826

Yu Feng

Great Bay University, Peoples Rep of China

Co-Author(s): Shuo Ling, Wenjun Ying, Zhennan Zhou

Abstract:

We present a robust computational framework for Hele-Shaw tumor growth with necrotic cores, a problem identified as the incompressible limit of the Porous Media Equation. Simulating this system presents a fundamental challenge: while the outer boundary evolves via advection, the inner necrotic interface is defined by an obstacle problem and lacks an explicit advection structure, causing standard schemes to fail. To address this, we introduce a stabilized predictor-corrector strategy that iteratively resolves the bidirectional coupling between the nutrient-pressure fields and the domain geometry, ensuring robust time-stepping for both the advection-driven outer surface and the obstacle-defined necrotic core. We establish rigorous convergence theory for the single-interface case and demonstrate the method's robustness in capturing the topological transition of necrotic core nucleation and complex geometric evolution.

Explicit Symmetric Low-Regularity Integrator for the Nonlinear Schrodinger Equation

Schedule: July 9 8:30-9:00 Room 826

Yue Feng

Xi'an Jiaotong University, Peoples Rep of China

Abstract:

The numerical approximation of low-regularity solutions to the nonlinear Schrodinger equation (NLSE) is notoriously difficult and even more so if structure-preserving schemes are sought. Recent works have been successful in establishing symmetric low-regularity integrators for NLSE. However, so far, all prior symmetric low-regularity algorithms are fully implicit, and therefore require the solution of a nonlinear equation at each time step, leading to significant numerical cost in the iteration. In this work, we introduce the first fully explicit (multi-step) symmetric low-regularity integrators for NLSE. We demonstrate the construction of an entire class of such schemes which notably can be used to symmetrise (in explicit form) a large amount of existing low-regularity integrators. We provide rigorous convergence analysis of our schemes and numerical examples demonstrating both the favourable structure preservation properties obtained with our novel schemes, and the significant reduction in computational cost over implicit methods.

Multi-fidelity numerical methods for a class of kinetic models

Schedule: July 9 8:30-9:00 Room 826

Liu Liu

The Chinese University of Hong Kong, Hong Kong

Abstract:

In this talk, we will discuss about a class of multi-fidelity numerical methods for solving kinetic models. In the first part, we will address the uncertainty quantification for kinetic problems and development of bi-fidelity or tri-fidelity methods for different models, where some error estimates are studied using the hypocoercivity. In the second part, we will study an efficient asymptotic-preserving scheme for solving the Boltzmann equation with bi-fidelity algorithm designed in the velocity discretization. Lastly, some applications to deep learning approaches for kinetic models will be discussed, with the idea of bi-fidelity introduced. These are joint works with Xueyu Zhu, Lorenzo Pareschi, Nicolas Crouseilles, Zhen Hao.

The unified gas kinetic wave-particle method for the neutron transport equation

Schedule: July 7 9:00-9:30

Yanli Wang

Beijing Computational Science Research Center, Peoples Rep of China

Co-Author(s): Guangwei Liu, Shuang Tan

Abstract:

The unified gas-kinetic wave-particle (UGKWP) method is proposed for the neutron transport equation, addressing the inherent multiscale nature of neutron propagation in both optically thin and thick regimes. UGKWP couples macroscopic diffusion and microscopic transport processes within a unified time-dependent framework, allowing a smooth transition between the free transport and diffusion regimes. This method is readily extended to multi-group neutron transport models and is applicable to both steady-state and eigenvalue problems. Several numerical examples, including the 1D and 3D single-group and 3D multi-group problems, are studied, indicating UGKWP a promising framework for scalable and accurate simulation of multigroup neutron transport in complex geometries.

Special Session 194 : The rigorous mathematical theory on the convergence in the fluid related model

Organizer(s): Feng Xie , Xiongfeng Yang

Introduction: The convergence between two different models is an important issue in mathematical theory. At the same time, they are always challenging analytical questions because the scaling variables and the degenerate of the systems. This session will show recent developments and advancements in the analysis of models, for example, the Navier-Stokes equations ,the kinetic equation. It is expected to bring together the researchers interested in these systems to discuss this topic, facilitate the emergence of new ideas, and inspire new research.

Global well-posedness of one-dimensional infrarelativistic model for a compressible viscous gas with radiation

Schedule: July 9 17:00-17:30 Room 421

Xin Liu

Shanghai University of International Business and Economics, Peoples Rep of China

Co-Author(s): Yuming Qin, Xiaolei Dong

Abstract:

This talk investigates the global well-posedness of the one-dimensional infrarelativistic model for a compressible viscous gas with radiation. Under suitable hypotheses on the transport coefficients, we prove the global existence and asymptotic behavior of solutions in H^i ($i = 1, 2, 4$) for this model.

Enhanced Dissipation and Global Well-Posedness for a Three-Dimensional Flame Propagation Model with Couette Flow

Schedule: July 9 17:30-18:00 Room 421

Lijuan Wang

Shanghai University of International Business and Economics, Peoples Rep of China

Abstract:

In this talk, we are concerned with a three-dimensional gravity-induced flame front model under a Couette flow. By exploiting the enhanced dissipation induced by the Couette flow, we prove global-in-time well-posedness of the Cauchy problem in $\mathbb{R}^3$ and derive decay estimates for the solution and its spatial derivatives in L^p norms for all $p \geq 1$. The analysis is based on a Green's function approach for the associated variable-coefficient linearized operator. These results show that enhanced dissipation induced by the Couette flow is the key mechanism leading to global existence in the whole space, in the large initial data regime. This talk is based on recent joint work with Professor Yoshiyuki Kagei

Suppression of blow-up in 3-D Keller-Segel system with fractional diffusion via Couette flow in whole space

Schedule: July 9 16:30-17:00 Room 421

Yucheng Wang

Shanghai University, Peoples Rep of China

Co-Author(s): Shijin Deng, Binbin Shi, Weike Wang

Abstract:

In this paper, we consider a Keller-Segel model with a fractional diffusion term in $\mathbb{R}^3$ in the background of a Couette flow. We show that when the background Couette flow is large enough, the dissipation enhancement induced could prevent the blow-up of solutions and thus prove the global existence and also obtain time decay rates of the solution in L^p norm. The main tool of the proof is a corresponding Green's function and the key estimate is its L^1 estimate without singularities at $t=0$. To fulfill such an estimate, we meet great troubles caused by the fractional heat kernel together with the Couette flow in the model considered here and overcome the troubles by introducing a space-frequency mixed decomposition. The main purpose of this paper is to develop a new microlocal analysis technique for researching the Green's functions with variable coefficients and strong singularities, such as the Green's function with shear flows. Obviously, this technique is crucial for capturing the dissipation enhancement mechanism of shear flows in the whole space.

Decoupled rotational Camassa-Holm approximation from the Green-Naghdi system with Coriolis effect

Schedule: July 9 18:00-18:30 Room 421

Xiongfeng Yang

Shanghai Jiao Tong University, Peoples Rep of China

Co-Author(s): Yue Liu

Abstract:

The present paper demonstrates the rigorously convergence from the Green-Naghdi (R-GN) system incorporating Coriolis effects to two counter-propagating wave packets governed by distinct rotational Camassa-Holm (R-CH) equations within the Camassa-Holm framework. The crucial observation is the construction of appropriate approximation functions to precisely characterize the nonlinear interaction dynamics between these bidirectional wave components. This mathematical framework extends the Camassa-Holm paradigm to rotational flows through careful modulation of wave dispersion and Coriolis coupling effects.

Special Session 195 : Calculus of Variations and Hyperbolic PDEs in Solid Mechanics

Organizer(s): Andreas Vekelis , Konstantinos Koumatos , Athanasios Tzavaras

Introduction: The study of dynamic elasticity is a cornerstone of applied mathematics and mechanics, providing fundamental models for materials capable of undergoing large deformations. Such phenomena arise naturally across a broad spectrum of physical, engineering, and biological systems. From a mathematical perspective, these processes are often described by evolutionary PDEs whose structure reflects underlying variational principles and geometric constraints. The interplay between hyperbolic PDEs and the calculus of variations has proven essential for understanding the qualitative behavior of these models. At the same time, increasingly complex material responses and multiscale effects pose new theoretical challenges that call for deeper connections between rigorous analysis and applications. This special session aims to bring together researchers working at this interface between analysis and solid mechanics. It will provide a forum to discuss recent advances in variational methods, hyperbolic PDE theory, and their role in the mathematical foundations of the mechanics of solids. The session brings together leading researchers who contribute both to the dynamical formulation, with applications ranging from elasticity and materials science to biological systems, and to the development of the theoretical and variational tools that make these advances possible.

Rate dependent dislocation dynamics and gradient flows of currents

Schedule: July 9 15:30-16:00 Room 821

Antonin Cesik

University of Warwick, England

Co-Author(s): Thomas Hudson, Malte Kampschulte, Filip Rindler

Abstract:

Dislocations are line defects in crystalline materials whose dissipative motion drives plastic deformation. Their evolution involves complex topological changes and the formation of singular geometries. In this talk, we propose a variational framework for rate-dependent dislocation dynamics with superlinear dissipation. Dislocations are modeled as integral currents, which naturally capture the underlying geometric singularities. The evolution is formulated as a generalized gradient flow of currents. A central difficulty is that the dissipation is not lower semicontinuous in the natural weak $\{\}^*$ topology, due to the rate dependence. To overcome this, we introduce an additional Young-measure structure for the velocity field, which captures the spatial micro-oscillations arising in the limit. The evolution is constructed via the Weighted-Energy-Dissipation (WED) variational approach, leading to solutions satisfying an energy--dissipation inequality.

Low Regularity Potentials in Heterogeneous Cahn--Hilliard Functionals

Schedule: July 9 14:30-15:00 Room 821

Jakob Deutsch

TU Wien, Austria

Co-Author(s): Riccardo Cristoferi, Luca Pignatelli

Abstract:

We investigate the Cahn--Hilliard functional, a prototypical model for liquid--liquid phase separation, in a highly irregular setting. In particular, we consider potentials of low regularity that vanish on space-dependent wells. Under very mild assumptions, we prove a robust compactness result. By slightly strengthening the regularity of the wells and the growth conditions of the potential near them, we then fully characterize the asymptotic behavior of the associated family of functionals via a Γ -convergence analysis.

Variational approaches to inertia, contact and limits

Schedule: July 9 13:30-14:00 Room 821

Malte Kampschulte

Charles University Prague, Faculty of Mathematics and Physics, Czech Rep

Abstract:

Variational approaches to inertia, contact and limits For static and quasi-static problems, (iterated) minimization has long been one of the most important tools to prove existence of solutions. The main advantage of these variational approaches is that they are able to deal with complicated nonlinearities and nonconvexities in a rather natural fashion, directly relying on the description of a problem in terms of its physical energy. In contrast, for dynamic problems, i.e. those involving inertia, such variational approaches so far have been much less useful in practical existence proofs. The aim of this talk is to present our recent and not so recent attempts at bridging this gap, using a time-delayed approach which uses energetical descriptions and minimization as both a modelling approach, as well as a way of showing existence of solutions. This will be illustrated in the example of viscoelastodynamics, where we can deal with situations such as contact that defy any approach based on linearization. Furthermore we will see how the same ideas can be used to study limit systems of parameter-dependent families of such problems in a similarly general fashion. This is based on joint works with, among others, B. Beneš, A. Čadež, G. Gravina, M. Kružík and S. Schwarzacher.

Geometric rigidity in variable domains and applications in dimension reduction

Schedule: July 9 17:00-17:30 Room 821

Leonard Kreutz

Technical University of Munich, Germany

Co-Author(s): Manuel Friedrich, Konstantinos Zemas

Abstract:

In this talk we present a quantitative geometric rigidity estimate in dimensions $d=2,3$ generalising a celebrated result by Friesecke, James and Müller to the setting of variable domains. Loosely speaking, we show that for each function $y \in H^1(U; \mathbb{R}^3)$ and for each connected component of an open bounded set $U \subset \mathbb{R}^d$, the L^2 -distance of ∇y from a single rotation can be controlled up to a constant by its L^2 -distance from the group $SO(d)$, with the constant not depending on the precise shape of U , but only on an integral curvature functional related to ∂U . We further show that for linear strains the estimate can be refined, leading to a uniform control independent of the set U . The estimate can be used to establish compactness in the space of generalized special functions of bounded deformation (GSBD) for sequences of displacements related to deformations with uniformly bounded elastic energy. We show how this estimate can be applied in the context of dimension reduction by calculating the Γ -limits for thin elastic solids containing voids in different energy scaling regimes in terms of their thickness. This is seminar based on joint work on with Manuel Friedrich (Johannes Kepler Universität Linz) and Konstantinos Zemas (Universität Bonn).

Frame-indifferent approximation in Nonlinear Thermoviscoelasticity

Schedule: July 9 8:30-9:00 Room 821

Lennart Machill

Rheinische Friedrich-Wilhelms-Universität Bonn, Germany

Abstract:

We consider a Kelvin-Voigt model for thermoviscoelastic second-grade materials, where the elastic and the viscous stress tensor both satisfy frame indifference. We prove the existence of weak solutions relying on an estimate due to Ciarlet and Mardare (2015), which generalizes the celebrated rigidity estimate of Friesecke, James, and Müller (2002). The estimate allows us to employ a staggered time-discretization scheme that preserves frame indifference, in which the deformation and the temperature are updated alternately. The talk is based on joint works with Manuel Friedrich, Martin Kružík, Rufat Badal, and Martin Horák.

Derivation of membrane models in nonlocal hyperelasticity

Schedule: July 9 17:30-18:00 Room 821

Anastasia Molchanova

TU Wien, Austria

Co-Author(s): Dominik Engl, Hidde Schönberger

Abstract:

Motivated by the analysis of thin structures, we study the variational dimension reduction of hyperelastic energies involving nonlocal gradients to an effective membrane model. When rescaling the thin domain, initially isotropic interaction ranges naturally become anisotropic, which leads us to develop a theory of anisotropic nonlocal gradients with direction-dependent interaction ranges. In contrast to existing nonlocal derivatives with finite horizon, which are typically defined via interaction kernels supported on balls of positive radius, our formulation employs ellipsoidal interaction regions whose principal radii may vanish independently. This yields a unified framework interpolating between fully nonlocal, partially nonlocal, and purely local models. Using these tools, we establish a Γ -convergence analysis for the associated nonlocal thin-film energies. The limit functional retains the structural form of the classical membrane energy, and the classical local model is recovered exactly when all interaction radii vanish. This talk is based on joint work with Dominik Engl and Hidde Schönberger.

Curvature-driven pattern formation in biomembranes: A gradient flow approach

Schedule: July 9 15:00-15:30 Room 821

Anastasija Pesic

WIAS Berlin, Germany

Abstract:

In this talk, we will present a phase-field model for curvature-driven pattern formation in biomembranes. The model is obtained as a gradient flow of an energy that approximates the two-phase Cahn-Hilliard functional, which leads to a Cahn-Hilliard-type equation with cross diffusion for the lipid concentration, coupled to a fourth-order equation for the membrane height. We establish existence and uniqueness of weak solutions for this system, both for regular and for singular potentials. In addition, we present numerical simulations that demonstrate how different parameter regimes give rise to striped, dotted, or snake-like patterns on the membrane. The talk is based on a joint work with Patrik Knopf and Dennis Trautwein

An existence theorem for time-dependent obstacle problems in viscoelasticity

Schedule: July 9 9:00-9:30 Room 821

Paolo Piersanti

The Chinese University of Hong Kong, Shenzhen, Peoples Rep of China

Abstract:

We establish the existence of solutions for a model describing the evolution of a linearly viscoelastic body which is constrained to remain confined in a prescribed half-space. The confinement condition under consideration is of Signorini type, and is given over the boundary of the linearly viscoelastic body under consideration. We show that one such variational problem admits solutions and we coin a novel concept of solution which, differently from the available literature, is valid even in the case where the viscoelastic body starts its motion in contact with the obstacle. Additionally, under additional assumptions on the constituting material, we show that when the applied body force is lifted the deformed linearly viscoelastic body returns to its rest position at an exponential rate of decay.

Time-Periodic Solutions for Hyperbolic-Parabolic Systems

Schedule: July 9 9:30-10:00 Room 821

Sebastian Schwarzacher

Uppsala University/Charles University, Sweden

Co-Author(s): Stanislav Mosny, Boris Muha, Justin T. Webster

Abstract:

Time-periodic weak solutions for a coupled hyperbolic-parabolic system are obtained. A linear heat and wave equation are considered on two respective d -dimensional spatial domains that share a common $(d-1)$ -dimensional interface. The system is only partially damped, leading to an indeterminate case for existing theory. We construct periodic solutions by obtaining novel a priori estimates for the coupled system, reconstructing the total energy via the interacting interface. As a byproduct, geometric constraints manifest on the wave domain which are reminiscent of classical boundary control conditions for wave stabilizability. We note a loss of regularity between the forcing and solution which is greater than that associated with the heat-wave Cauchy problem. However, we consider a broader class of spatial domains and mitigate this regularity loss by trading time and space differentiations, a feature unique to the periodic setting. This seems to be the first constructive result addressing existence and uniqueness of periodic solutions in the heat-wave context, where no dissipation is present in the wave interior.

Global Weak Solutions for Korteweg-Type Fluid Models

Schedule: July 9 18:00-18:30 Room 821

Stefano Spirito

University of L'Aquila, Italy

Abstract:

We present recent results on the global-in-time existence of finite-energy weak solutions for some compressible fluid models with capillarity, allowing for density-dependent and possibly degenerate viscosity coefficients. The analysis combines energy methods with entropy structures and compactness techniques, yielding a robust existence theory under minimal regularity assumptions.

Regular solutions and long-time dynamics in nonlinearly coupled thermoelasticity

Schedule: July 9 16:30-17:00 Room 821

Srdan Trifunovic

Faculty of Sciences, University of Novi Sad, Yugoslavia

Co-Author(s): Piotr Michał Bies, Tomasz Cieślak, Mario Fuest, Johannes Lankeit, Boris Muha

Abstract:

In this talk, I will present a recent result on a nonlinearly coupled thermoelasticity system. The first part of the result concerns existence and uniqueness of regular solutions, while the second one concerns long-time dynamics. The result is based on a novel functional involving the Fisher information associated with temperature, and its boundedness plays a key role in the result.

Stability effect in elasticity

Schedule: July 9 8:00-8:30 Room 821

Dehua Wang

University of Pittsburgh, USA

Abstract:

Elasticity is important in continuum mechanics with a wide range of applications and is challenging in analysis. In this talk we shall discuss some special elastic effects in elastic fluids, including the stabilizing effect of elasticity on the vortex sheets in compressible elastic flows and on the vanishing viscosity process of compressible viscoelastic flows.

Energy barriers for boundary nucleation in solid-solid phase transitions

Schedule: July 9 14:00-14:30 Room 821

Konstantinos Zemas

University of Bonn, Germany

Co-Author(s): Antonio Tribuzio

Abstract:

We study energy-scaling laws for a simplified, singularly perturbed, double-well nucleation problem confined in a half-space, in the absence of gauge invariance and for an inclusion of fixed volume. Motivated by models for boundary nucleation of a single-phase martensite inside a parental phase of austenite, our main focus is how the relationship between the rank-1 direction and the orientation of the half-space influences the energy scaling with respect to the fixed volume of the inclusion. Up to prefactors depending on this relative orientation, the scaling laws coincide with the corresponding ones for bulk nucleation, for all rank-1 directions, but the ones normal to the confining hyperplane. In the latter, the scaling is as in a three-well problem in full space, resulting in a lower energy barrier. This is joint work with A. Tribuzio (Uni-Bonn).

Special Session 197 : Intelligent Control and Game Theory

Organizer(s): Shujun Wang , Guangchen Wang , Tianyang Nie

Introduction: Amid the rapid evolution of AI, digital economy, and energy internet, intelligent decision-making and multi-agent coordination under multi-source uncertainty are key to upgrading critical sectors. Traditional model-driven control falls short in high-dimensional, nonlinear, and uncertain environments. Therefore, intelligent control must serve as the core, addressing controller design, stability, and adaptive optimization to build a robust theoretical framework for next-generation systems. Multi-agent collaborative optimization and game decision-making integrate mathematics, control science, and computer science, forming a unified framework to tackle swarm intelligence challenges in dynamic, interactive, and uncertain settings. However, intelligent control strategies and game equilibrium computation remain computationally intensive. Developing efficient algorithms is essential for theoretical advancement. This special session aims to present frontier progress and explore future directions in intelligent control and game theory, emphasizing an integrated theory-algorithm-application chain. Topics include stochastic control, intelligent control, stochastic differential games, filtering, smart energy, intelligent manufacturing, transportation, digital economy, FinTech, and optimization algorithms.

Numerical Methods for Mean-Field Forward-Backward Stochastic Differential Equations

Schedule: July 9 13:30-14:00 Room 822

Yinggu Chen

Ocean University of China, Peoples Rep of China

Co-Author(s): Lifeng Wei

Abstract:

Mean-field forward-backward stochastic differential equations (FBSDEs) serve as a core mathematical framework in mean-field game theory with broad applications in finance and large population systems. By leveraging the connection between FBSDEs and high-dimensional partial differential equations, deep learning algorithms can effectively circumvent the curse of dimensionality. However, existing numerical methods train neural network parameters separately on each time subinterval, causing parameter proliferation as time partitions become finer and leading to unstable computational accuracy. To address this issue, we note that under Markovian coefficient conditions, there exists a unique function u such that $Y_t = u(t, X_t)$ over the entire time interval, enabling consistent parameter training and significantly improving numerical accuracy. This result also holds when mean-field terms are expressed in distribution form, provided that certain regularity conditions are satisfied. Furthermore, the convergence from theoretical solutions to discretized equations is studied, and the convergence of neural network solutions with respect to the proposed loss function is analyzed. Several numerical examples are provided to validate the effectiveness of the method.

Indefinite Linear-Quadratic Mean-Field Game of Regime-Switching System

Schedule: July 9 9:30-10:00 Room 822

Kai DU

Shandong University, Peoples Rep of China

Abstract:

In this talk, we introduce an indefinite mean-field game with Markov jump parameters. One notable aspect is the relaxation of the assumption regarding the positivity or non-negativity of weight matrices within costs. By virtue of mean-field methods and decomposition techniques, we have derived decentralized strategies presented by Hamiltonian systems and a new type of consistency condition system. These systems consist of fully coupled regime-switching forward-backward stochastic differential equations that do not conform to the Monotonicity condition. The well-posedness of these strategies is established by employing a relaxed compensator method with an easily verifiable Condition (RC) and the decomposition technique. Furthermore, we demonstrate that the resulting decentralized strategies achieve an epsilon-Nash equilibrium in the indefinite case without any assumptions on admissible control sets using novel estimates of the disturbed state and cost function.

Optimal Cybersecurity Investment with Risk Sharing

Schedule: July 8 13:30-14:00 Room 822

Zhuo Jin

Macquarie University, Australia

Abstract:

We study the optimal timing for a firm to invest in cybersecurity technology while managing cyber risk through insurance. Cyber losses are modeled as a jump process to capture fat-tailed behavior, and investment costs evolve stochastically via a compound Poisson process due to technological uncertainty. The firm aims to minimize total expected costs, including losses, investment, and insurance premiums. By formulating an optimal stopping problem and solving the corresponding Hamilton-Jacobi-Bellman equations, we obtain semi-closed-form solutions for the value function and optimal strategies. Numerical examples illustrate how key factors, such as loss intensity, insurance coverage, and cost volatility, affect investment timing and risk-sharing decisions.

Linear-Quadratic Stochastic Stackelberg Games of N Players for Time-Delay Systems and Related FBSDEs

Schedule: July 8 16:30-17:00 Room 822

Na Li

Dalian University of Technology, Peoples Rep of China

Co-Author(s): Shujun Wang

Abstract:

Motivated by the multi-scheme supply chain problem, a linear-quadratic generalized Stackelberg game for time-delay is studied, in which the multi-level hierarchy structure with delay is involved. With the help of the continuity method, we first establish the unique solvability of nonlinear anticipated forward-backward stochastic delayed differential equations with a multi-level self-similar domination-monotonicity structure. Based on it, we derive the Stackelberg equilibrium in this framework. By the theoretical results, a corporate social responsibility problem is studied in the view of a multi-scheme supply chain problem, some simulations are also presented to illustrate the Stackelberg equilibrium in a special case.

The Deep Truncated FBSDE Method: A Robust Solver for High-dimensional PDEs

Schedule: July 8 17:00-17:30 Room 822

Yunzhang Li

Fudan University, Peoples Rep of China

Abstract:

The curse of dimensionality makes it difficult to solve high-dimensional partial differential equations (PDEs) numerically. The nonlinear Feynman-Kac formula gives a probabilistic link between these PDEs and forward-backward stochastic differential equations (FBSDEs), but classical deep-learning solvers often become unstable for strongly coupled problems. We introduce a Deep Truncated FBSDE method for high-dimensional quasilinear PDEs that overcomes these limitations. The method uses the gradient truncation and applies iterative decoupling to separate the forward and backward parts, reducing unstable feedback between them. We also rewrite the PDE as equivalent coupled subsystems that are easier to optimize and enforce pathwise consistency through repeated refinement to control errors. Theoretical results and numerical tests show this method improves stability, convergence, and accuracy, offering a scalable and reliable tool for high-dimensional problems.

Optimal Information Disclosure In A Stackelberg Game

Schedule: July 8 17:30-18:00 Room 822

Ruyi Liu

University of New South Wales, Australia

Co-Author(s): Zhou Zhou

Abstract:

We investigate a leader-follower game in which the leader hires the follower to complete a project in the presence of a random shock time. If the project is completed before the shock time, then both players receive (up to discounting) \$1 each. If it is completed after the shock time, then the leader and the follower receive \$y and \$x respectively. The shock time is observable by the leader, but not by the follower. The leader chooses how to reveal the information of the shock time, and the follower controls the effort level which affects the project completion time. The goal is to find the leader's value and optimal information disclosure strategy. By considering the leader's value as a function of the follower's utility as well as the follower's belief about the shock time, we characterize the leader's value using dynamic programming equations. The leader's (e-)optimal strategy can also be constructed from these equations.

Policy Optimization in the Linear Quadratic Gaussian Problem: A Frequency Domain Perspective

Schedule: July 8 15:30-16:00 Room 822

Yuan-Hua Ni

Nankai University, Peoples Rep of China

Co-Author(s): Haoran Li, Xun Li, Yuan-Hua Ni, Xuebo Zhang

Abstract:

The Linear Quadratic Gaussian (LQG) problem is a classic and widely studied model in optimal control, providing a fundamental framework for designing controllers for linear systems subject to process and observation noises. In recent years, researchers have increasingly focused on directly parameterizing dynamic controllers and optimizing the LQG cost over the resulting parameterized set, whereas this parameterization typically gives rise to a highly non-convex optimization landscape for the resulting parameterized LQG problem. To our knowledge, there is currently no general method for certifying the global optimality of candidate controller parameters in this setting, and most existing numerical methods lack rigorous guarantees of global convergence. In this work, we address these gaps with the following contributions. First, we derive a necessary and sufficient condition for the global optimality of stationary points in a parameterized LQG problems. This condition reduces the verification of optimality to a test of the controllability and observability for a novel, specially constructed transfer function, yielding a precise and computationally tractable certificate. Furthermore, our condition provides a rigorous explanation for why traditional parameterizations can lead to suboptimal stationary points. Second, we elevate the controller parameter space from conventional finite-dimensional settings to the infinite-dimensional $\mathcal{RH}_{\infty}$ space and develop a gradient-based algorithm in this setting, for which we provide a theoretical analysis establishing global convergence. Finally, representative numerical experiments validate the theoretical findings and demonstrate the practical viability of the proposed approach.

Partial stabilizability of forward-backward systems and stabilizability of game-based control systems

Schedule: July 9 14:00-14:30 Room 822

Yuanzhuo Song

Shenzhen University, Peoples Rep of China

Co-Author(s): Kai Du

Abstract:

We introduce three types of stabilizability for controlled forward-backward stochastic differential equations (FBSDEs): weak stabilizability, stabilizability and strong stabilizability. To investigate the weak stabilizability and stabilizability of FBSDEs, we focus on the partial stabilizability of the associated controlled linear systems, which can be characterized by some linear matrix inequality. Similarly, to address the strong stabilizability of FBSDEs, we define the concept of invariant stabilizability for controlled linear systems, which is described by some mild algebraic criteria. In addition, the stabilizability of game-based control systems (GBCSs) is studied, and by virtue of using the maximum principle, we reduce the analysis of these stabilizability types for GBCSs to the corresponding stabilizability of controlled FBSDEs. Finally, for the specific GBCS, we give the corresponding numerical simulation results to verify the accuracy of our theoretical results.

Resilient Event-Triggered Data-Driven LFC under DoS Attacks

Schedule: July 8 15:00-15:30 Room 822

Weiwei Sun

Qufu Normal University, Peoples Rep of China

Abstract:

This talk presents a resilient event-triggered load frequency control (LFC) scheme for multi-area power systems under DoS attacks, using only input-output data. Unlike existing methods that rely on average dwell time, we directly analyze how attack patterns interact with event-triggered mechanisms. This allows us to distinguish valid and invalid time intervals within attack periods that truly affect system dynamics. Based on this, we propose an attack compensation recovery strategy within a model-free adaptive control framework, where both the controller and parameter estimator are reconstructed using the last successfully transmitted signal before an attack. A recursive analysis then gives a sufficient condition for tracking error boundedness, linking stability to the ratio of valid to invalid time during attacks. Simulations on multi-area power systems validate the effectiveness of the approach.

Unknown Input State Observer Based on a Closed-Form Transformation and the Kalman Filter

Schedule: July 9 8:00-8:30 Room 822

Huaibin Tang

Shandong University, Peoples Rep of China

Co-Author(s): Qinghua Zhang

Abstract:

This paper considers robust state estimation for continuous time-varying systems involving arbitrary unknown inputs and random noises. After a time-varying transformation decoupling the system from the unknown inputs, the Kalman filter is applied to the transformed system before recovering the state of the original system. With the decoupling transformation in a simple closed-form, the computational cost of the whole algorithm is close to that of the classical Kalman filter. Under assumptions involving a Gramian matrix similar to the classical observability Gramian, it is shown that the proposed algorithm is an asymptotically unbiased state estimator, i.e., the mathematical expectation of the state estimation error converges exponentially to zero, and the covariance of the state estimation error is bounded. Simulation examples illustrate the effectiveness of the proposed algorithm.

A new PINNs algorithm for solving MFGs

Schedule: July 9 14:30-15:00 Room 822

Shupeng Wang

Shandong University, Peoples Rep of China

Co-Author(s): Zhen Wu, Hui Zhang

Abstract:

Mean field games are frameworks to study Nash equilibria or social optima in games with a continuum of agents. These problems can be used to approximate competitive or cooperative games with a large finite number of agents and have found a broad range of applications, in particular in economics. In this work, we consider a mean field games systems with non-local coupling terms involving M populations. State-of-the-art numerical methods for solving such problems exploit spatial discretization, which leads to the curse of dimensionality and computational scale. We propose a new physics informed neural networks for solving considered systems. It is proved that the standard gradient descent for the proposed method converges to the global optimum of the loss with an appropriate choice of the learning rate. In view of the study on the construction and scarcity of multi-population mean field games, the effectiveness of our method is demonstrated by solving single-population mean-field game systems in 1, 2, and 100 dimensions, and then applied to solving the mean field games systems with 50 and 100 populations. These results open the door to much-anticipated applications of multi-population mean field games that are beyond the reach of existing numerical methods.

Linear Quadratic Optimal Control Problems for Conditional Mean-Field Stochastic Differential Equations Under Partial Information

Schedule: July 9 8:30-9:00 Room 822

Hua Xiao

Shandong University, Peoples Rep of China

Co-Author(s): Siqi Feng, Guangchen Wang, Hua Xiao, Zhuangzhuang Xing, Huanjun Zhang

Abstract:

This talk centers on a kind of linear quadratic stochastic optimal control problem driven by conditional mean-field stochastic differential equations under partial information. In this context, the cost functional is permitted to be indefinite. At the outset, we present a broad overview of optimal control with the aid of the adjoint equation. However, the Hamiltonian system poses a challenge as it incorporates two distinct conditional expectations, making decoupling unattainable. To tackle this, we extract and analyze three representative cases derived from practical problems, discussing each case separately. We find that, in any case, the uniform convexity of the cost functional ensures the existence of a unique optimal control with a state feedback form for the problem, which is a weaker assumption compared to the standard one. Finally, we apply the obtained results to address specific issues raised in the initial motivations of this paper. These applications demonstrate the practical relevance and effectiveness of our theoretical findings in addressing real-world challenges in the field of stochastic optimal control.

Innovation Incentive Game for Key Core Technology Innovation Based on Multi-Dimensional Private Information

Schedule: July 9 9:00-9:30 Room 822

Detao Zhang

Shandong University, Peoples Rep of China

Co-Author(s): Juankai Ding, Ziang Duan, Detao Zhang

Abstract:

Innovation is the fundamental driver of long-term economic growth and the enhancement of social welfare. However, innovation does not occur spontaneously; the rational decisions of individual firms often deviate from the socially optimal outcome, making government intervention indispensable. Yet, information asymmetry between the government and firms makes it difficult for the government to accurately assess firms' technological capabilities and true costs, thereby hindering the design of effective incentive measures and giving rise to adverse selection. To address this, this paper constructs an innovation incentive game framework that covers the entire process of technological innovation-technology industrialization-downstream demand cultivation, and systematically explores how the government can implement appropriate subsidies when firms possess multi-dimensional private information, thereby inducing firms to voluntarily disclose their true information and engage in innovation activities.

Simultaneous identifiability of piecewise-constant reaction coefficient and initial condition in a reaction--diffusion equation

Schedule: July 8 14:00-14:30 Room 822

Zhi-Xue Zhao

School of Mathematical Sciences, Tianjin Normal University, Peoples Rep of China

Abstract:

This talk addresses the inverse problem of simultaneously identifying a piecewise-constant reaction coefficient and the initial condition in a one-dimensional reaction--diffusion equation, using only boundary control and observation data. We propose a novel ON/OFF control strategy combined with an estimation/cancellation mechanism. This approach decomposes the problem of simultaneous identifiability into two sequential subproblems: first, uniquely determining the reaction coefficient; second, reconstructing the initial value. By applying Property C, we establish the unique identifiability of the piecewise-constant reaction coefficient. The initial value is then recovered via spectral analysis. A key advantage of our framework is its exclusive reliance on boundary data, eliminating the need for interior measurements and thereby enhancing practical applicability.

Output regulation problem for passive systems with strong stability

Schedule: July 8 14:30-15:00 Room 822

Huacheng Zhou

Central South University, Peoples Rep of China

Abstract:

In this paper, we present output regulator problem for an impedance passive linear plant, using the classical resonant internal model based controller. The reference and disturbance signals are assumed to be linear combinations of sine waves of known frequencies. We prove that (under suitable mild assumptions, but without any stability assumptions for the plant) this controller leads to a strongly stable closed-loop system and it solves the output regulator problem if the concept of "the error converges to zero" is defined in a suitable way: low-pass filtering the error with any low-pass filter gives a continuous signal that tends to zero. We give two examples (both models of engineering systems) to illustrate the results.

Abstracts for Contributed Sessions

Contributed Session 1 : ODEs and Applications

Introduction:

Results on Behavior of Solutions of Third Order Delay Differential Equations

Schedule: July 8 9:40-10:00 Room 634

Adetunji A Adeyanju

Federal University of Agriculture Abeokuta, Nigeria

Abstract:

This paper aims at investigating certain criteria for obtaining uniform-asymptotically stable and uniform-ultimate bounded solutions to certain third order delay differential equation. Using a newly constructed Lyapunov-Krasovskii functional, we prove these criteria and validate them with two numerical examples. The results expand upon earlier findings in the field.

Self-adjoint differential-algebraic operators with boundary terms

Schedule: July 7 16:30-16:50 Room 634

Zhanar Artykbayeva

Institute of Mathematics and Mathematical Modeling, Almaty, Kazakhstan

Abstract:

We consider a differential-boundary equation with algebraic terms on a finite interval $0 < x < 1$

$$\begin{equation} \begin{split} l(y) \equiv \frac{d}{dx} \biggl(\frac{dy(x)}{dx} \biggr) + \sum_{i=1}^k h_i(x) U_i(y) + \\ \sum_{j=1}^s \lambda_j q_j(x) \biggr) + r_1(x) \frac{dy(x)}{dx} + r_0(x) y(x) = f(x), \end{split} \end{equation}$$

A distinctive feature of these equations is that, alongside the function being sought, a certain number of unknown values must also be determined. This leads to the critical question of unique solvability: how many and what type of conditions need to be imposed on equation (1) to ensure that the resulting problem has a unique solution in a given space? Such equations, consisting of both differential and algebraic parts, are usually called differential-algebraic equations [1,2].

Response solutions of a class of nonlinear quasi-periodic systems with multi-dimensional Liouvillean frequency

Schedule: July 8 9:00-9:20 Room 634

Zhi Cheng

School of Mathematics, Southeast University, Peoples Rep of China

Co-Author(s): Dongfeng Zhang

Abstract:

We study the reducibility of a class of nonlinear quasi-periodic systems near an elliptic equilibrium point with multi-dimensional Liouvillean basic frequencies, and investigate the existence of response solutions for such systems. Under a non-resonance condition weaker than the Brjuno condition, which allows for a class of multi-dimensional Liouvillean frequencies, we prove via the KAM method that for most sufficiently small parameters, the system can be reduced to a system with zero as its equilibrium point, and thus the original system admits the corresponding response solutions.

Ulam-Hyers-Rassias stability of Caputo fractional differential equations with deviating arguments on unbounded intervals.

Schedule: July 7 16:50-17:10 Room 634

Natalia Dilna

Institute of Mathematics of the Slovak Academy of Sciences, Slovak Rep

Abstract:

Ulam-Hyers-Rassias stability of non-local problems for differential equations with Caputo fractional derivatives involving (non-delay) deviating arguments on unbounded intervals is investigated in [1]. By applying the Banach fixed-point theorem, we establish conditions for the existence and uniqueness of mild solutions within the space of continuous functions endowed with the Bielecki norm. This kind of stability is important in applications where exact solutions are difficult to obtain and numerical or approximate solutions are commonly used. We emphasized that, in the analysis of UHR stability, the solution of the non-local problem depends on a function that satisfies the differential inequality. This result extends existing theory by establishing more generalized stability results for Caputo fractional differential equations with (non-delay) deviating arguments and non-local conditions on infinite domains. [1] Dilna N., Langerova M. Ulam-Hyers-Rassias stability of Caputo fractional differential equations with deviating arguments on unbounded intervals, *Mathematica Slovaca*, 2026, to appear.

Universality and hysteresis in slow sweeping of bifurcations

Schedule: July 8 8:20-8:40 Room 634

Omri Gat

The Hebrew University of Jerusalem, Israel

Co-Author(s): Roie Ezraty and Ido Levin

Abstract:

While attractors of dissipative dynamical systems describe their long-time behavior, bifurcations are often studied experimentally by dynamically sweeping structural parameters. If the parameter sweep is slow enough, the system follows adiabatically the time-dependent attractor. However, the time scale for convergence to the attractor typically diverges near the bifurcation, so that the adiabatic approximation fails near the bifurcation, and parameter sweep cannot directly reconstruct the bifurcation diagram; in particular, the system follows distinct trajectories during an upward and downward sweep through the bifurcations. In the context of period-doubling and pitchfork bifurcations, I will show that full bifurcation structure can nevertheless be recovered by reducing the system to a time-dependent normal form with universal families of upsweep and downsweep trajectories that depend on a small sweep rate parameter s . The area of the hysteresis loop in phase space that serves as an experimental measure of the effective sweep rate tends to zero in the slow sweep limit as $s^{1/4}$ times a distinctive logarithmically divergent factor.

The formal ultra-differential normalization for random dynamical systems

Schedule: July 9 13:50-14:10 Room 634

Weifang Hu

School of Mathematics, Southeast University, Peoples Rep of China

Co-Author(s): Hao Wu

Abstract:

We present a framework for establishing ultradifferential normal forms on various tempered neighborhoods for random dynamical systems. More precisely, we provide sharper estimates of the loss of ultra-differential smoothness by small divisor conditions, tempered neighborhood, and the order of non-resonant terms based on the Lyapunov exponents of linear parts. The tools utilised here are ergodic theorems and fixed point theorems on weighted Banach spaces.

Robustly chaotic dynamics in networks of phase oscillators

Schedule: July 7 17:10-17:30 Room 634

Aleksei Kazakov

National Research University Higher School of Economics, Russia

Abstract:

One of the most fundamental problems in multi-dimensional chaos theory is the study of strange attractors which are robustly chaotic (i.e., they remain chaotic after small perturbations of the system). It was hypothesized in [1] that the robustness of chaoticity is equivalent to the pseudohyperbolicity of the attractor. Pseudohyperbolicity is a generalization of hyperbolicity. The main characteristic property of a pseudohyperbolic attractor is that each of its orbits has a positive maximal Lyapunov exponent. In addition, this property must be preserved under small perturbations. The foundations of the theory of pseudohyperbolic attractors were laid by Turaev and Shilnikov, who showed that the class of pseudohyperbolic attractors, besides the classical Lorenz and hyperbolic attractors, also includes wild attractors which contain orbits with a homoclinic tangency. In this talk, using the pseudohyperbolicity notion, we will explain how to check whether the attractor is robustly chaotic or not. We will describe the corresponding numerical methods and apply them for the study of networks of coupled phase oscillators. This work was supported by the project Mirror Laboratories at HSE University. References 1. Gonchenko S., Kazakov A. and Turaev D., 2021. Wild pseudohyperbolic attractor in a four-dimensional Lorenz system. *Nonlinearity*, 34(4), p.2018.

Fractal dimension and control of Julia set of the discrete fractional disease model

Schedule: July 8 8:40-9:00 Room 634

Manoj Kumar

Indian Institute of Technology Mandi, India

Co-Author(s): Syed Abbas

Abstract:

The filled Julia set of the complex map is defined as the set of initial points such that trajectories starting from this point will be bounded. Its boundary, known as the Julia set, characterizes the intricate interface between stable and unstable dynamics, while its complement forms the Fatou set. These sets encode essential information about the global behavior of nonlinear systems and provide a geometric framework for understanding boundedness and stability. We examine the fractal behavior in a nonlinear discrete fractional disease model. We take a specific one that depicts a fractional tumor-immune interaction, and the same analysis will work for other suitable types of fractional disease models. Firstly, we take the Caputo fractional order tumor-immune model. The corresponding discrete fractional model is then determined using the Caputo definition. The escape-time algorithm is used to generate the Julia set of the discrete fractional model. In our study, we design two novel controllers based on the fixed-point and discrete fractional models and add these two novel controllers in distinct ways. We notice the different effects of the controllers by adding them to different parts of the system. We also used coordinate transformation to design the controller, which helps to control the Julia set using the stability of the fixed point. Finally, the simulations help in the study of the effectiveness of each controller towards the control of fractal behaviors.

Generic symplectic homeomorphisms

Schedule: July 9 14:10-14:30 Room 634

Joao J Lopes Dias

Universidade de Lisboa, Portugal

Co-Author(s): M Bessa, M J Torres

Abstract:

We introduce symplectic homeomorphisms to state the following generic dynamical property in the C^0 topology: the special shadowing property. This relates to properties that, for diffeomorphisms, are consequences of hyperbolicity. In this weaker topology we guarantee the same qualitative behaviour in the generic sense without any hyperbolicity assumptions.

Bounded Non-response solutions with Liouvillean forced frequencies for nonlinear Schrödinger equations on $\mathbb{T}$

Schedule: July 7 17:30-17:50 Room 634

Fuzheng Ma

School of Mathematics, Southeast University, Peoples Rep of China

Co-Author(s): XinDong Xu

Abstract:

This paper is concerned with the existence and C^∞ smoothness of bounded non-response solutions for forced nonlinear Schrödinger equations on $\mathbb{T}$. The proof is based on an infinite dimensional KAM Theorem with multiple Imaginary normal frequency.

Conformable Control of Unmanned Ground Vehicles

Schedule: July 9 13:30-13:50 Room 634

Ozkan Ozturk

Giresun University, Turkey

Co-Author(s): Ali Akgul

Abstract:

This study investigates the control problem of a well-established unmanned ground vehicle (UGV) model within the framework of conformable fractional calculus, with particular emphasis on local and global stability analyses. The effectiveness and robustness of the proposed control strategies are first demonstrated through numerical simulations under local stability conditions. The analysis is then extended to the global setting, where further simulations validate the theoretical results by confirming system convergence over a wide range of initial conditions.

Transcritical and Pitchfork Bifurcations in Scalar Nonautonomous Difference Equations

Schedule: July 9 14:30-14:50 Room 634

David Rackl

University of Klagenfurt, Austria

Co-Author(s): David Rackl

Abstract:

We study transcritical and pitchfork bifurcations in scalar nonautonomous difference equations. In the nonautonomous setting, these bifurcations are no longer described by isolated equilibria, but by bounded solutions and their stability properties. Using explicitly solvable model equations as prototypes, we show that classical bifurcation scenarios persist via comparison with these model systems under suitable spectral and nonlinear balance conditions. Our approach is local in nature and applies when the dichotomy spectrum reduces to a single point, which allows it to depend smoothly on the parameter under additional summability assumptions. Finally, we discuss the structural limitations of this approach, particularly when hyperbolicity is lost over a parameter interval, and indicate how it fits into the broader landscape of nonautonomous bifurcation theory.

Finite-dimensional Approximation of Attractors

Schedule: July 7 17:50-18:10 Room 634

ANDREI SULTAN

Moldova State University, Vladimir Andrunachievici Institute of mathematics, Moldova

Co-Author(s): David Cheban

Abstract:

The aim of this talk is to study the finite-dimensional approximations of the nonautonomous lattice dynamical systems of the form
$$u_i' = \nu(u_{i-1} - 2u_i + u_{i+1}) - \lambda u_i + F(u_i) + f_i(t) \quad (i \in \mathbb{Z}).$$
 We show that the finite-dimensional approximations for are uniformly dissipative. The upper semi-continuous convergence of the attractors of the finite-dimensional approximations is established.

Hyperbolicity for dynamics on Banach spaces: generalized

$(C,$
 $\lambda)$

-structure.

Schedule: July 8 9:20-9:40 Room 634

Sergey Tikhomirov

Pontificia Universidade Catolica do Rio de Janeiro - PUC-Rio, Brazil

Abstract:

We introduce a notion of generalized (C, λ) -structure for nonlinear diffeomorphisms of Banach spaces. The main differences to the classical notion of hyperbolicity are that we allow the hyperbolic splitting to be discontinuous and invariance condition assume only inclusions instead of equalities for both stable and unstable subspace. These aspects allow us to cover Morse-Smale systems and generalized hyperbolicity. We suggest that the generalized (C, λ) -structure for infinite-dimensional dynamics plays a role similar to "Axiom A and strong transversality condition" for dynamics on compact manifolds. For diffeomorphisms of reflexive Banach space we showed that generalized (C, λ) -structure implies Lipschitz (periodic) shadowing and is robust under C^1 -small perturbations. Assuming that generalized (C, λ) -structure is continuous for diffeomorphisms of arbitrary Banach spaces we obtain a weak form of structural stability: the diffeomorphism is semiconjugated from both sides with any C^1 -small perturbation.

Finitude of Limit Cycles of Linear Piecewise Odes in the Cylinder

Schedule: July 9 14:50-15:10 Room 634

Roberto Trinidad-Forte

Universitat de les Illes Balears, Spain

Co-Author(s): J.L. Bravo & R. Trinidad-Forte

Abstract:

Let $x' = S(t, x)$ be a differential equation in the cylinder, linear piecewise in x and with trigonometric coefficients in t . We provide an upper bound on the number of limit cycles in terms of the number of zones of the piecewise equation and the degree of the coefficients, that is, an analog of Hilbert's 16th problem in this context.

Controllability and Hyers-Ulam Stability Analysis of Fractional q-Difference System

Schedule: July 7 18:10-18:30 Room 634

Bhawna Verma

Indian Institute of Technology Mandi, India

Co-Author(s): Muslim Malik

Abstract:

The mathematical problem of controllability refers to the ability to steer the state of a dynamical control system from a given initial state to a desired final state using a control parameter. In recent years, fractional q-difference equations have attracted considerable attention due to their effectiveness in describing dynamical systems within the framework of q-calculus. The main focus of this talk is to discuss the controllability and Hyers-Ulam stability of an implicit coupled fractional q-difference system. The objective of the presentation is to present conditions for the existence and uniqueness of solutions, as well as the controllability and stability properties of the proposed system. For this purpose, tools from nonlinear functional analysis, fixed-point theory, and q-calculus are used. In particular, the contraction mapping principle is applied to obtain controllability results, while the Schauder fixed-point theorem is used to discuss the existence of solutions and the Hyers-Ulam stability of the system.

Emergent Dynamics of the Kuramoto Model with Adaptive and Time-delay Couplings

Schedule: July 9 15:10-15:30 Room 634

Yu-Qing Wang

University of L'Aquila, Italy

Co-Author(s): Jiu-Gang Dong, Cristina Pignotti

Abstract:

We study the emergent dynamics for the time-delayed Kuramoto model with adaptive couplings. Sufficient frameworks for practical and complete phase synchronization are established in terms of initial configurations and system parameters. For a heterogeneous ensemble, we demonstrate that practical phase synchronization occurs under both Hebbian and anti-Hebbian adaptive couplings when the initial phase diameter is confined within $\frac{\pi}{2}$. For a homogeneous ensemble with zero natural frequencies, complete phase synchronization is guaranteed unconditionally. Specifically, this synchronization is achieved for Hebbian coupling when the initial historical phase diameter-defined as the maximum phase disparity evaluated over the initial delay window-is below $\frac{\pi}{2}$, and for anti-Hebbian coupling when this historical diameter is bounded by π . Furthermore, for a homogeneous ensemble with non-zero natural frequencies and uniform time delays, we prove that complete phase synchronization occurs exponentially under both adaptive rules when initial phases are confined in a quarter circle. Finally, numerical simulations are provided to demonstrate our theoretical results.

Stochastic bifurcations of a three-dimensional stochastic Kolmogorov system

Schedule: July 7 18:30-18:50 Room 634

Chenwan Zhou

New York University Shanghai, Peoples Rep of China

Co-Author(s): Dongmei Xiao, Deng Zhang, Chenwan Zhou

Abstract:

We study stochastic bifurcations of ergodic stationary measures and stochastic dynamics of a stochastic Kolmogorov system. There exists a threshold noise intensity σ_0 such that when $\sigma \geq \sigma_0$, the noise destroys all deterministic bifurcations; when $0 < \sigma < \sigma_0$, the unique ergodic measure bifurcates into three types of ergodic measures.

Contributed Session 2 : PDEs and Applications

Introduction:

Analysis of a Coupled Cahn-Hilliard Cross-Diffusion System for Lipid Raft-Receptor Dynamics on Cell Membranes

Schedule: July 6 13:30-13:50 Room 635

Tarek Acila

University of Warwick, England

Co-Author(s): Tarek Acila

Abstract:

We present a thermodynamically consistent coupled PDE system on a closed surface modelling the interplay between lipid raft phase separation and receptor dynamics on a cell membrane. The model is derived via Onsager's Variational Principle, coupling Cahn-Hilliard equation for lipid ordering to a cross-diffusion system for three receptor states with mixing entropies, volume-filling constraints, and raft-receptor interactions. The system features degenerate mobilities, logarithmic singularities, and equations of mixed second- and fourth-order. Existence of weak solutions is established via techniques from boundedness-by-entropy methods, adapted to the structure and couplings of the system. Uniform energy-entropy estimates are derived to control solutions in appropriate function spaces. At the time-discrete level, auxiliary regularised systems are defined and solved using fixed-point arguments. The entropy variables for the second-order equations are inverted algebraically, while a variational minimisation argument exploits the natural two-sided Flory-Huggins barrier in the fourth-order receptor equation, enforcing strict positivity of receptor fractions. An energy convex splitting is employed for the Cahn-Hilliard equation, giving unconditional stability of the discrete scheme, while the degenerate mobility yields the physically required bound on the order parameter. Compactness arguments allow passage to the limit in approximation parameters, recovering global weak solutions.

A Posteriori Error Analysis of the Nitsche Method for the Stokes-Poisson-Boltzmann System with Navier Slip Boundary Conditions

Schedule: July 6 16:30-16:50 Room 635

Ayush Agarwal

Indian Institute of Technology Roorkee, India

Abstract:

We study the Stokes-Poisson-Boltzmann equations with mixed Dirichlet and Navier boundary conditions. The system consists of the incompressible Stokes equations coupled with a nonlinear Poisson-Boltzmann equation through electrostatic forcing and convective transport effects. To handle the Navier boundary conditions in a unified framework, we employ Nitsche's method for their weak imposition within a conforming finite element setting. We derive a consistent and stable discrete formulation and establish the well-posedness of the resulting problem. By carefully choosing the penalty parameters, the bilinear form is shown to be coercive and continuous. A priori error estimates are proved in the natural energy norms, yielding optimal-order convergence under suitable regularity assumptions. Furthermore, we develop residual-based a posteriori error estimators that incorporate element residuals, inter-element jump terms, and boundary contributions arising from the Nitsche formulation. The estimators are shown to be reliable and locally efficient, providing a rigorous basis for adaptive mesh refinement. Numerical experiments confirm the theoretical results and demonstrate the robustness and accuracy of the proposed method for the Stokes-Poisson-Boltzmann system.

Existence and Uniqueness Analysis of a Nonlinear Biphasic Mixture Model

Schedule: July 7 8:00-8:20 Room 635

Meraj Alam

Mahindra University, Hyderabad, India

Co-Author(s): Meraj Alam, Adrian Muntean, G. P. Raja Sekhar

Abstract:

This work is concerned with the development and analysis of a mathematical model motivated by interstitial hydrodynamics and tissue deformation mechanics (poroelastohydrodynamics) within an in-vitro solid tumour. The classical mixture theory is employed to derive the mass and momentum balance equations for a two-phase system. A key contribution of this study is the treatment of the physiological transport parameter, namely the hydraulic resistivity, as anisotropic and heterogeneous, which leads to a strongly coupled and nonlinear system. We derive the corresponding weak formulation and reformulate the problem as an equivalent fixed-point problem. This framework enables the application of the Galerkin method together with classical results on monotone operators and the Schauder and Banach fixed-point theorems to establish the existence and uniqueness of solutions.

A PDE Perspective on Averaging for Slow-fast Systems

Schedule: July 7 13:30-13:50 Room 635

Ashot Aleksian

Heriot-Watt University, Scotland

Co-Author(s): Michela Ottobre

Abstract:

Many systems in applied sciences involve multiple interacting scales, and a natural goal is to derive effective descriptions capturing the influence of fast variables on slower ones. We consider stochastic systems with slow and fast components. It is well known that the evolution of their law is described by a Fokker-Planck equation, yielding an equivalent PDE formulation. In the classical case where the fast process admits a unique invariant measure, time-scale separation allows one to replace it in the effective dynamics by the equilibrium behavior. The averaged dynamics can be derived using PDE techniques, in particular multiscale expansions and the associated Poisson equation. We finally discuss the case where the fast dynamics admits multiple invariant measures. In this regime, standard averaging techniques break down. This issue arises, for instance, in McKean-Vlasov type equations.

On the asymptotic behavior of solutions to a dissipative nonlocal NLS type equation

Schedule: July 8 8:00-8:20 Room 635

Brahim Alouini

University of Monastir, Faculty of Sciences of Monastir, Research Laboratory Analysis, Probabilities and Fractals
LR18ES17, Tunisia

Abstract:

This talk addresses the long-time dynamics of a damped nonlinear Schrödinger type equation on $\mathbb{R}$ involving a nonlocal integral term. Under the minimal assumption on the external source and for a broad class of smooth subcritical nonlinearities, we prove, using a recent idea, the existence of a compact global attractor and an exponential attractor in the Sobolev space $H^1(\mathbb{R})$. Moreover, combining quasi-stability and localization arguments, we derive explicit upper bounds on the Hausdorff and fractal dimensions of the global attractor in terms of the physical parameters.

Stochastic Homogenization of Nonconvex Unbounded Integral Functionals with Generalized Orlicz Growth

Schedule: July 8 13:30-13:50 Room 635

Davide Aruta

Scuola Superiore Meridionale, Italy

Co-Author(s): Francesca Prinari, Francesco Solombrino

Abstract:

We consider the homogenization of random integral functionals which are possibly unbounded, that is, the domain of the integrand is not the whole space and may depend on the space-variable. In the vectorial case, we develop a complete stochastic homogenization theory for nonconvex unbounded functionals with convex growth of generalized Orlicz-type, under a standard set of assumptions in the field, in particular a coercivity condition of order $p^- > 1$, and an upper bound of order p^+ .

Well-posedness of three-dimensional Damped Cahn-Hilliard-Navier-Stokes Equations

Schedule: July 7 9:40-10:00 Room 635

Manika Bag

Indian Institute of Science Education and Research, Thiruvananthapuram, India

Co-Author(s): Manika Bag, Sheetal Dharmatti, Manil T Mohan

Abstract:

This paper presents a mathematical analysis of the evolution of a mixture of two incompressible, isothermal fluids flowing through a porous medium in a three-dimensional bounded domain. The model is governed by a coupled system of convective Brinkman-Forchheimer equations and the Cahn-Hilliard equation, considering a regular potential and non-degenerate mobility. We first establish the existence of a Leray-Hopf weak solution for the coupled system when the absorption exponent $r \geq 1$. Additionally, we prove that every weak solution satisfies the energy equality for $r \geq 3$. This further leads to the uniqueness of weak solutions in three-dimensional bounded domains, subject to certain restrictions on the viscosity (ν) and the Forchheimer coefficient (β) in the critical case $r = 3$. Similar results are also obtained for the case of degenerate mobility and singular potential.

Global Well-posedness and decay of the Westervelt-hyperbolic Pennes system

Schedule: July 8 16:30-16:50 Room 635

Imen BENABBAS

University of Science and Technology Houari Boumediene, Algeria

Co-Author(s): Belkacem SAID-HOUARI

Abstract:

We consider a system coupling the Westervelt equation with a hyperbolic version of the Pennes bioheat equation. This model describes the heating generated by the propagation of nonlinear ultrasonic waves through thermo-viscous media, which has many industrial and medical applications. More precisely, the equations are coupled through the dependence of the coefficients in the Westervelt equation on the temperature and through a source term in the Pennes equation accounting for the absorbed acoustic energy. Using energy methods together with a continuity argument, we prove the global well-posedness of the system under consideration. To this end, we establish time-independent energy estimates that ensure uniform boundedness of the solution for all times. In addition, by relying on Sobolev embeddings and interpolation inequalities, global well-posedness is achieved under a smallness assumption imposed only on suitable lower-order norms of the initial data. Furthermore, by combining the derived estimates with a Gronwall-type inequality, we show the exponential decay of the solution to the steady state.

Generalized BMO-type seminorms and vector-valued Sobolev functions

Schedule: July 9 8:00-8:20 Room 635

Konstantinos Bessas

University of Pavia, Italy

Co-Author(s): Serena Guarino Lo Bianco (University of Modena and Reggio Emilia) and Roberta Schiattarella (University of Naples Federico II)

Abstract:

We prove an existence theorem for the pointwise limit of a wide class of one-parameter *BMO*-type seminorms as the parameter goes to zero. We generalize results appearing in the literature by introducing novel *BMO*-type seminorms and extending our analysis to vector-valued functions. We then prove a characterization result of some Sobolev-type spaces of vector-valued maps based on the asymptotic behavior of suitable *BMO*-type seminorms. As an application of these results, given an open set $\Omega \subseteq \mathbb{R}^n$ and $p \in (1, \infty)$, we establish a non-distributional characterization of both the Sobolev space $W^{1,p}(\Omega; \mathbb{R}^m)$ and the space $E^{1,p}(\Omega; \mathbb{R}^n)$ of L^p functions whose distributional symmetric gradient is p -integrable. Moreover, when $p \in [1, \infty)$, for both spaces we show how the corresponding *BMO*-type seminorms can be used to approximate certain positive, convex and p -homogenous functionals closely related to the L^p norms of the distributional (symmetric) gradients.

Bridging machine learning and stabilized FEM: a hybrid PINN-SUPG framework for 3D transport equations

Schedule: July 9 13:30-13:50

Suleyman Cengizci

Antalya Bilim University, Turkey

Abstract:

Advection-dominated convection--diffusion and convection--diffusion--reaction equations in three spatial dimensions present persistent numerical challenges, particularly in regions characterized by sharp boundary layers, internal shocks, and steep solution gradients. Classical stabilized finite element methods, such as the streamline-upwind/Petrov--Galerkin (SUPG) formulation augmented with discontinuity-capturing operators, effectively suppress spurious oscillations inherent in standard Galerkin (GFEM) approximations. However, these advanced stabilization mechanisms may introduce excessive numerical dissipation that smears sharp fronts and compromises solution accuracy in critical regions. This work presents a novel two-stage hybrid computational framework that synergistically combines the robustness of stabilized finite element methods with the approximation capabilities of Physics-Informed Neural Networks (PINNs) for solving three-dimensional transport problems. In the first stage, the SUPG formulation enhanced with a $YZ\beta$ discontinuity-capturing operator is employed to obtain numerically stable preliminary solutions. While this approach successfully eliminates non-physical oscillations, it may introduce artificial diffusion, particularly in regions featuring steep gradients. In the second stage, a PINN-based correction mechanism is deployed to identify and mitigate the excessive dissipation introduced by the stabilization procedure. The neural network architecture incorporates Fourier feature embeddings for enhanced high-frequency representation and deep residual blocks for improved gradient flow. A multi-phase adaptive weight scheduling scheme is implemented to gradually transition from data-dominant to physics-dominant training, ensuring stable convergence while maintaining physical consistency. Numerical experiments on benchmark three-dimensional advection-dominated problems demonstrate that the proposed hybrid framework achieves superior accuracy in boundary layer regions compared to standalone SUPG- $YZ\beta$ solutions. The methodology successfully balances the trade-off between numerical stability and solution accuracy, producing oscillation-free results with sharply resolved gradients. All finite element computations are performed using the FEniCS platform, while PINN training is conducted in PyTorch with full GPU acceleration.

Finsler N -Laplace equations with critical exponential nonlinearity

Schedule: July 9 16:30-16:50

Monti Das

Indian Institute of Technology Guwahati, India

Co-Author(s): Sweta Tiwari

Abstract:

We study some anisotropic equations involving the Finsler N -Laplace operator $\Delta_{H,N}$, with Trudinger-Moser type critical exponential nonlinearity which involves the anisotropic norm. More precisely, we establish the existence of nontrivial solutions to the problem
$$-\Delta_{H,N} u = f(x, u), \quad u \geq 0, \quad \text{on a smooth bounded domain } \Omega \subset \mathbb{R}^N, \quad N \geq 2,$$
 and to the anisotropic quasilinear Schrödinger type problem
$$u + V(x) |u|^{N-2} u = g(x, u), \quad u \geq 0, \quad \text{in the whole Euclidean space } \mathbb{R}^N.$$
 Here $\Delta_{H,N} u = \operatorname{div}(H(\nabla u)^{N-1} \nabla_{\xi} H(\nabla u))$ is known as Finsler N -Laplacian or anisotropic N -Laplacian, $H : \mathbb{R}^N \rightarrow [0, \infty)$ is a positively homogeneous Minkowski norm, and ∇_{ξ} denotes the gradient operator with respect to the ξ variable. The nonlinearities f and g exhibit critical exponential type growth, and the potential V is a continuous function that retains the compactness of the associated Sobolev embedding into a larger class of Lebesgue spaces under suitable assumptions.

Large Solutions for Linear and Semi-linear Equations Involving Fractional Laplacian on Infinite Cylinder

Schedule: July 6 13:50-14:10 Room 635

N N Dattatreya

Indian Institute of Technology Kanpur, India

Co-Author(s): Indranil Chowdhury

Abstract:

Solutions of differential equations that blow up on the boundary of a domain are called large solutions or boundary blow-up solutions. We investigate large solutions for the fractional Laplacian on a sequence of cylinders $B_1^{n-1}(0) \times [-\ell, \ell]$ as $\ell \rightarrow +\infty$ and obtain large solutions on infinite cylinder $\Omega_\infty := B_1^{n-1}(0) \times \mathbb{R}$ to the following problem

$$\left\{ \begin{array}{l} (-\Delta)^s u = f(x, u) \quad \text{in } \Omega_\infty, \quad u = g \quad \text{in } \mathbb{R}^n \setminus \Omega_\infty, \quad \delta_{\Omega_\infty}^s(x) u(x) \xrightarrow[x \rightarrow \theta]{x \in \Omega_\infty} h(\theta) \quad \text{for } \theta \in \partial\Omega_\infty, \end{array} \right.$$

under suitable assumptions on (f, g, h) . The investigation is carried out for both linear and semi-linear equations. Further, for a linear equation, we identify three distinct types of large solutions on an infinite cylinder. These are solutions arising from the data $(f, 0, 0)$, $(0, g, 0)$, and $(0, 0, h)$.

Numerical Solution of Caputo-Type Advection--Diffusion Equations via Shifted Chebyshev Pseudospectral Methods and Sylvester Equations

Schedule: July 6 16:50-17:10 Room 635

Francisco de la Hoz

University of the Basque Country, Spain

Co-Author(s): Peru Muniain

Abstract:

Let $\alpha \in (0, \infty)$ satisfy $n - 1 < \alpha < n$ for some $n \in \mathbb{N}$. The Caputo fractional derivative of order α for a function $f \in \mathcal{C}^n(0, \infty)$ is defined as

$$D_t^\alpha f(t) = \frac{1}{\Gamma(n - \alpha)} \int_0^t \frac{f^{(n)}(\tau)}{(t - \tau)^{1 - n + \alpha}} d\tau.$$

Similarly, for $\alpha \in (0, \infty)$ and $f \in \mathcal{C}^0(0, \infty)$, the Riemann--Liouville fractional integral of order α is given by

$$I_t^\alpha f(t) = \frac{1}{\Gamma(\alpha)} \int_0^t \frac{f(\tau)}{(t - \tau)^{1 - \alpha}} d\tau.$$

In this talk, we present a pseudospectral approach to construct operational matrices based on shifted Chebyshev polynomials for the numerical approximation of Caputo fractional derivatives and Riemann--Liouville fractional integrals. To ensure numerical stability in the construction of these matrices, we employ variable precision arithmetic. We then apply the resulting Caputo differentiation matrices to solve Caputo-type advection--diffusion equations in one and multiple spatial dimensions, where the discretization reduces to a Sylvester (tensor) equation. Numerical experiments involving highly oscillatory time-dependent functions demonstrate the accuracy, stability, and effectiveness of the proposed method.

On a Matrix-Based Spectral Approximation of the Fractional Laplacian and Fractional p -Laplacian on $\mathbb{R}^n$

Schedule: July 7 8:20-8:40 Room 635

Francisco de la Hoz

University of the Basque Country, Spain

Co-Author(s): Loïc Constantin, Carlota M. Cuesta

Abstract:

Given a function u defined on $\mathbb{R}^n$, its fractional p -Laplacian is given by

$$(-\Delta)_p^s u(\mathbf{x}) = C_{n,s,p} \text{P. V.} \int_{\mathbb{R}^n} \frac{|u(\mathbf{x}) - u(\mathbf{y})|^{p-2} (u(\mathbf{x}) - u(\mathbf{y}))}{\|\mathbf{x} - \mathbf{y}\|^{n+sp}} d\mathbf{y}, \quad \mathbf{x} \in \mathbb{R}^n,$$

where the integral is understood in the principal value sense, $p \in (1, \infty)$, $s \in (0, 1)$, and $C_{n,s,p}$ is a normalization constant depending on n , s , and p . An equivalent formulation is given by the nonlinear Balakrishnan formula:

$$(-\Delta)_p^s u(\mathbf{x}) = \tilde{C}_{n,s,p} \int_0^\infty \Delta(t - \Delta)^{-1} [\Phi_p(u(\mathbf{x}) - u(\cdot))](\mathbf{x}) \frac{dt}{t^{1-sp/2}}$$

where $\tilde{C}_{n,s,p}$ is another normalization constant, and $\Phi_p(t) = |t|^{p-2}t$. In the linear case $p = 2$, this reduces to the classical fractional Laplacian. In this talk, we present a matrix-based spectral method for the numerical approximation of both the fractional Laplacian and the fractional p -Laplacian for functions defined on $\mathbb{R}^n$. Our approach builds on the Balakrishnan representation, where we discretize the second-order derivatives in Δ using spectrally accurate differentiation matrices. A key advantage is that these matrices can be diagonalized in a well-conditioned manner, enabling a stable and robust numerical scheme that naturally extends to arbitrary spatial dimensions n . The method avoids multidimensional quadrature, domain truncation, and variational formulations, making it both computationally efficient and conceptually straightforward.

Asymptotic analysis of Steklov eigenvalues in a thin multidomain

Schedule: July 7 13:50-14:10 Room 635

Bauyrzhan Derbissaly

Institute of Mathematics and Mathematical Modeling, Kazakhstan

Abstract:

In this work, we investigate the asymptotic behavior of the eigenvalues of the classical Steklov problem in a thin multidomain as the thickness parameter tends to zero. The multidomain consists of two vertically aligned cylinders, one placed above the other. We show that the eigenvalues converge to zero as the domain becomes thinner. In this setting, the limiting eigenvalue problem in the upper cylinder reduces to a one-dimensional problem, whereas the limiting problem in the lower cylinder is posed on an $(n - 1)$ -dimensional ball. Finally, we consider the case in which the upper and lower cylinders have the same order of thickness.

On damped fractional Navier-Stokes equations

Schedule: July 7 16:50-17:10 Room 635

Tomasz W. Dlotko

Institute of Mathematics, University of Silesia in Katowice, Poland

Abstract:

Global existence of strong solutions to the Navier-Stokes equations is one of the main open problems in analysis. Embedding the original Navier-Stokes equations into two parameter family of its fractional damped generalizations, we study how the parameters determine properties of solutions to the 3D Dirichlet problem. The roles of the strengthened viscosity and the damping term are analyzed.

On chaos, transient chaos and ghosts in single population models with Allee effects

Schedule: July 8 16:50-17:10 Room 635

Jorge Duarte

Instituto Superior de Engenharia de Lisboa, Portugal

Abstract:

Density-dependent effects, both positive or negative, can have an important impact on the population dynamics of species by modifying their population per-capita growth rates. An important type of such density-dependent factors is given by the so-called Allee effects, widely studied in theoretical population biology. The study of transient dynamical phenomena near bifurcation thresholds has attracted the interest of many researchers due to the relevance of bifurcations in different physical or biological systems. In the context of saddle-node bifurcations, where two or more fixed points collide annihilating each other, it is known that the dynamics can suffer the so-called delayed transition. This phenomenon emerges when the system spends a lot of time before reaching the remaining stable equilibrium, found after the bifurcation. The time delay scales according to an inverse square-root power law. In this work, we characterize analytically this scaling law using complex variable techniques for a family of one-dimensional maps. We show that the numerical results are in perfect agreement with the provided analytical solutions. The procedure presented in this work can be used to characterize the scaling laws of one-dimensional discrete dynamical systems with saddle-node bifurcations, particularly single population models with Allee effects.

Nonlinear elliptic equations with singular potentials and gradient-dependent nonlinearities

Schedule: July 8 8:20-8:40 Room 635

Maria Farcaseanu

The University of Sydney, Australia & ISMMA, Romania, Australia

Abstract:

We establish the existence of distinct asymptotic profiles near the origin for positive radial solutions of the nonlinear elliptic equation $\Delta u + (2 - N - 2\rho) \frac{x \cdot \nabla u}{|x|^2} + \frac{\lambda}{|x|^2} u = |x|^\theta u^q |\nabla u|^m$ in $B_R(0) \setminus \{0\}$, where $\rho, \lambda, \theta, m, q \in \mathbb{R}$, $m > 0$, $q \geq 0$ and $m + q - 1 > 0$. Moreover, we derive refined asymptotic behavior for each of these profiles. This is joint work with Florica Cîrstea (The University of Sydney).

Relaxation limits of a viscoelastic phase separation model to three classical phase separation models

Schedule: July 8 13:50-14:10 Room 635

Moritz Immanuel Gau

WIAS Berlin, Germany

Co-Author(s): Katharina Hopf

Abstract:

Viscoelastic phase separation can be observed in binary mixtures, whose two components have strongly different aggregation time scales. The morphology exhibits features such as volume shrinking, thin network-like structures and phase inversion. Such effects play a crucial role for instance, in the formation of membraneless protein organelles. We consider a non-degenerate variant of a model proposed by Zhou et al. 2006 with gradient-flow structure, that comprises a Cahn--Hilliard equation for the phase variable u with a nonlinear cross-coupling to the spherical bulk stress q , which itself obeys relaxational dynamics. Introducing a small characteristic size $q_c := \varepsilon$ of q and rescaling the relaxation coefficient and the time, we rigorously pass to the limit $\varepsilon \rightarrow 0$. We show that $q \rightarrow 0$ and, depending on the scaling relations, u converges to a solution of either (i) the Cahn--Hilliard equation, (ii) the viscous Cahn--Hilliard equation, or (iii) the mass-preserving Allen--Cahn equation. The analysis is based on the gradient-flow equation and a precise determination of the limiting subdifferential in each scaling regime.

Quantum mechanical closure of partial differential equations with symmetries

Schedule: July 9 8:20-8:40 Room 635

Dimitris Giannakis

Dartmouth College, USA

Co-Author(s): David Freeman, Joanna Slawinska, Chris Vales

Abstract:

We present a framework for closure of spatiotemporal dynamics governed by partial differential equations based on quantum mechanics. This approach builds quantum mechanical systems that are embedded within the discretization mesh of the coarse model, and act as data-driven surrogate models for the unresolved degrees of freedom of the original dynamics. The coupled classical--quantum system evolves through a prediction--correction cycle, whereby the quantum mechanical models provide estimates of the subgrid fluxes through expectation values of quantum observables, and the classical coarse model conditions the quantum mechanical states via a quantum mechanical Bayes rule. Moreover, by combining methods from operator-valued kernels and delay embedding, the quantum mechanical systems capture a compressed representation of the dynamics that is positivity-preserving and invariant under spatial symmetries of the original dynamics. We illustrate this scheme with applications to closure of the shallow-water equations in a periodic domain.

A space-time discontinuous Galerkin method for parabolic problems on moving domains with agglomerated polytopic meshes

Schedule: July 9 13:50-14:10

Xinping gui

Scuola Internazionale Superiore di Studi Avanzati (SISSA), Italy

Co-Author(s): Andrea Cangiani, Alessandro Poletto

Abstract:

We consider a hp-version space-time discontinuous Galerkin (DG) method for solving time-dependent problems on moving domains. The method employs a fitted mesh approach, where the mesh is adapted to conform to the evolving geometry of the domain at each time step. An agglomeration strategy is introduced for handling cut cells, improving numerical stability and performance. The approach combines high-order space-time discretization with hp-adaptivity to achieve optimal convergence rates for parabolic problems. The resulting method allows for precise mesh refinement in regions of interest, resolving steep solution gradients and reduced-regularity features. Numerical experiments indicate efficient performance and stable behaviour across representative test cases.

Elliptic and Parabolic Problems Involving the Anisotropic $\vec{p}(u)$ -Laplacian

Schedule: July 9 16:50-17:10

Shilpa Gupta

Indian Institute of Technology, India

Co-Author(s): Kaushik Bal

Abstract:

In this talk, I will discuss a class of elliptic and parabolic partial differential equations characterized by anisotropic $\vec{p}(u)$ -Laplace operator, where the vector-valued exponent $\vec{p} = (p_1, \dots, p_N)$ depends on the unknown function u and a non-local function of u , respectively. This dependence necessitates the use of variable exponent Sobolev spaces specifically tailored to the anisotropic framework and destroys the homogeneity and standard convexity properties of the operator, making the analysis substantially more delicate. For the elliptic case, we discuss the existence of a weak solution by employing the theory of pseudomonotone operators in conjunction with suitable approximation techniques. In the parabolic setting, the existence of a weak solution will be discussed via a time discretization scheme and Schauder fixed-point theorem, supported by a priori estimates and compactness arguments.

Orbiting solitons in Kerr cavities with anomalous GVD

Schedule: July 6 14:10-14:30 Room 635

Salim B Ivars

ICFO, Spain

Co-Author(s): Salim B. Ivars, David Artigas, Carlos Mas Arab^{\{i\}} and Carles Mili^{\`an}

Abstract:

In this work we introduce a new class of dynamic dissipative soliton in driven passive cylindrical microresonators. The combination of modulation of the input pump with the polychromatic conical radiation tails emitted due to the third order dispersion is able to stabilise cluster soliton arrangements in which individual soliton orbit within the structure in closed trajectories. This unexpected dynamics leads to slow soliton revivals where solitons periodically appear and disappear at fixed extraction points. This results in much longer timescales than the roundtrip time, allowing the generation of high-resolution frequency combs where the free spectral range is of several orders of magnitude smaller than the one fixed by the geometry of the cavity. This ability to control instabilities and induce nontrivial soliton motion opens new paradigms for frequency comb generation with enhanced spectral control for applications.

H-convergence theory for anisotropic bending rods

Schedule: July 6 17:10-17:30 Room 635

Jelena Jankov Pavlovic

School of Applied Mathematics and Informatics, Croatia

Co-Author(s): Kresimir Burazin; Matko Ljulj; Josip Tambaca

Abstract:

We investigate H-convergence for a fourth-order system of one-dimensional equations modeling the bending of anisotropic elastic rods with axially varying coefficients. The model is obtained via dimension reduction of three-dimensional linearized elasticity with variable cross-sections and leads to a coupled system for transversal displacements governed by a matrix-valued bending tensor. We introduce a notion of H-convergence adapted to this fourth-order rod system and prove a compactness result. Owing to the one-dimensional structure of the domain, the analysis simplifies compared with higher-dimensional problems: strong convergence of the stress sequence replaces the compensated compactness arguments typically required in multidimensional settings. As a consequence, we show that the H-limit of any bounded sequence of uniformly elliptic bending tensors can be identified explicitly and is given by the harmonic mean, even without periodicity assumptions. In addition, the key structural properties of H-convergence, such as locality, preservation of ellipticity bounds, and independence of boundary conditions, remain valid in this framework. These results provide a homogenization theory for fourth-order rod operators and yield an explicit characterization of the effective bending tensor. Possible applications are in optimal design problems, where homogenization is a well-established tool for relaxation and was the original motivation of Tartar and Murat for introducing H-convergence.

Wave-number-explicit analysis for maxwell's equation with DtN truncation

Schedule: July 7 8:40-9:00 Room 635

Xue Jiang

Beijing University of Technology, Peoples Rep of China

Abstract:

This work is focused on the propagation of electromagnetic waves in R^3 described by Maxwell's equation with large wave number and Silver-Muller radiation condition. The model problem is approximated by truncating the exact Dirichlet-to-Neumann (DtN) operator into a finite sum of vector spherical harmonics. We prove the well-posedness and wave-number-explicit $H(\text{curl})$ -stability of the solution to truncated problem by assuming that the truncation number N satisfies $N \leq akR$ for some $a > 1$, where k represents the wave number and R is the radius of the physical domain. Additionally, we demonstrate that the truncated solution is exponentially close, in terms of N , to the true scattering solution. Finally, we present the hp-finite element method (hp-FEM) for the truncated problem, along with its asymptotic error estimate. Some numerical experiments are provided to validate the theoretical findings.

A domain hemivariational inequality for 2D and 3D convective Brinkman-Forchheimer extended Darcy equations

Schedule: July 7 14:10-14:30 Room 635

Jyoti Jindal

Indian Institute of Technology, Roorkee, India

Co-Author(s): Sagar Gautam and Manil T. Mohan

Abstract:

This paper investigates domain hemivariational inequality problems arising from the non-stationary two- and three-dimensional convective Brinkman-Forchheimer extended Darcy (CBFeD) equations, which describe the flow of viscous incompressible fluids through saturated porous media in bounded domains. These equations may be regarded as generalized Navier-Stokes systems incorporating both damping and pumping mechanisms. For all admissible absorption exponents $r \geq 1$ and effective viscosity $\mu > 0$, the existence of weak solutions to the non-stationary 2D and 3D CBFeD equations with hemivariational inequalities is established via a regularized Galerkin approximation scheme, based on a suitable regularization of the Clarke subdifferential. A noteworthy aspect of the analysis is that the existence results extend to the three-dimensional non-stationary Navier-Stokes equations. Moreover, under appropriate conditions on the absorption exponent, specifically, $r \geq 1$ in two dimensions and $r \geq 3$ in three dimensions, it is shown that weak solutions satisfy the energy equality. In addition, uniqueness of solutions is proved for $r \geq 1$ in 2D and $r \geq 3$ in 3D, with the additional requirement $2\beta\mu > 1$ in the critical case $r = 3$.

POINTWISE TRACKING APPROXIMATE CONTROLLABILITY FOR THE CAHN-HILLIARD EQUATION

Schedule: July 8 8:40-9:00 Room 635

Greeshma K

Indian Institute of Science Education and Research, Thiruvananthapuram, India

Co-Author(s): Dharmatti Sheetal

Abstract:

We study an approximate controllability problem for the Cahn-Hilliard equation with terminal time observations at a finite number of spatial points. More precisely, for fixed time T and a given $\varepsilon > 0$, we investigate whether the solution of the system reaches the ε -neighbourhood of the desired state at predetermined finitely many points. In the first problem, we consider the admissible control set to be L^2 . As a first step, we prove approximate controllability of the associated linearised system, through a variational approach, by introducing a suitable convex functional involving solutions of the adjoint equation with Dirac-type terminal data. The result is then extended to the semilinear system by using a fixed-point argument. Moreover, we study the controllability problem for control acting at finitely many spatial points along with pointwise observations. In this setting, the pointwise evaluation of the state requires additional regularity of the solution; hence, we prove the result only for the linear model. To tackle finite pointwise control, we write the pointwise control as the limit of specific L^2 controls and use previously obtained results. Further, by employing compactness arguments, we conclude the approximate controllability.

Unconditionally stable numerical solution for the high-order Allen-Cahn equation

Schedule: July 8 14:10-14:30 Room 635

Seungyoon Kang

National Institute for Mathematical Sciences, Korea

Co-Author(s): Junseok Kim

Abstract:

We present an unconditionally stable algorithm for the Allen--Cahn (AC) equation incorporating a high-order free energy formulation. This high-order AC model enhances the preservation of interfacial dynamics and effectively suppresses noise. The proposed scheme guarantees unconditional stability, which is crucial for accurate phase transition modeling and maintaining fine structural details. To solve the governing equation efficiently, it is split into two subproblems that are solved independently. The nonlinear term is treated using a frozen coefficient approach, followed by an analytical solution. The linear term is solved using the discrete cosine transform. To demonstrate the effectiveness of the method, we perform several numerical simulations in both two- and three-dimensional domains. Thanks to its unconditional stability, the algorithm allows large time steps without compromising stability. Furthermore, we explore the distinct features of the high-order AC equation, particularly its improved capability to model phase separation under strong noise and intricate interface structures.

Asymptotic Stability towards superposition of rarefaction and shock of the 1D Jin-Xin relaxation model for the p-system

Schedule: July 7 16:30-16:50 Room 635

Nayeon Kim

KAIST, Korea

Co-Author(s): Masaya Kageura, Moon-Jin Kang, Yoshihiro Ueda

Abstract:

The Jin-Xin relaxation model is a semilinear hyperbolic system designed to approximate nonlinear hyperbolic conservation laws. This talk focuses on the one-dimensional Jin-Xin model for the p-system. We show that when initial data stay near a superposition of rarefaction and shock, the solution converges to the superposition where the shock is shifted by a time-dependent shift. This is joint work with Masaya Kageura (Kobe University), Moon-Jin Kang (KAIST), Yoshihiro Ueda (Kobe University).

Numerical solution of Korteweg-de Vries equation with moving boundaries

Schedule: July 8 17:10-17:30 Room 635

Nurbol Koshkarbayev

Institute of Mathematics and Mathematical Modeling, Kazakhstan

Abstract:

This talk presents a numerical approach for solving the Korteweg-de Vries (KdV) equation on a time-dependent domain with moving boundaries. The KdV equation is fundamentally given by $u_t + \alpha uu_x + \beta u_{xxx} = 0$. While problems on fixed domains are well-studied, moving boundaries introduce significant analytical and computational challenges. To address this, we map the non-cylindrical moving boundary domain into a fixed reference domain using a coordinate transformation. We then apply a Galerkin finite-element formulation based on cubic B-spline basis functions for spatial discretization, and a Crank-Nicolson scheme for temporal integration. Numerical simulations, including benchmarking against known solutions, are provided to illustrate wave dynamics and the interaction of solutions with the boundaries. The results demonstrate that the proposed method attains high accuracy and efficiency for tracking nonlinear waves in non-cylindrical domains.

Initial layer for the Boltzmann equation

Schedule: July 9 8:40-9:00 Room 635

Hung-Wen Kuo

National Cheng Kung University, Taiwan

Abstract:

In studying the relation between the Boltzmann equation in kinetic theory and fluid dynamics, it is crucial to understand the singular layers that appear in the Boltzmann solutions. These include the boundary, shock, and initial layers, which become singular when the mean free path is small. The present work focuses on the initial layer, whose main feature is the propagation of discontinuities in the solutions of the Boltzmann equation. To analyze the global structure of Boltzmann solutions, it is essential to describe these discontinuities precisely in both the space-time variables and the microscopic velocity. We construct the explicit form of the Green's function and use it to represent the Boltzmann solution. The quantitative structure of this Green's function enables a detailed analysis of the commutator between the nonlinear collision operator and the transport operator, providing a precise understanding of the propagation of discontinuities. Our results reveal both the explicit form and kinetic nature of these discontinuities, as well as the emergence of fluid-like waves in the initial layer. This explicit construction bridges the Boltzmann equation and hydrodynamic behavior. This work is in collaboration with Tai-Ping Liu and Shih-Hsien Yu.

Global existence for a nonisothermal and conserved phase field system with inertial term

Schedule: July 9 14:10-14:30

Shunsuke Kurima

Kanagawa University, Japan

Co-Author(s): Pierluigi Colli

Abstract:

In this talk we deal with a conserved phase field system that couples the energy balance equation with a Cahn--Hilliard type system including temperature and the inertial term for the order parameter. In the case without inertial term, the system under study was introduced by Caginalp. The inertial term is motivated by the occurrence of rapid phase transformation processes in nonequilibrium dynamics. In this talk we prove global existence of solutions to a nonisothermal and conserved phase field system with inertial term via the analysis of some approximate problems with Yosida regularizations, and the use of the Cauchy--Lipschitz--Picard theorem in an abstract setting. This is a joint work with Professor Pierluigi Colli (University of Pavia).

Thermodynamical Allen-Cahn equation with general polynomial free energy

Schedule: July 9 17:10-17:30

Gyeonggyu Lee

National Institute for Mathematical Science, Korea

Co-Author(s): Seunggyu Lee

Abstract:

The Allen-Cahn equation was originally introduced to model of antiphase domain coarsening in a binary mixture in materials science. It is applied to various scientific fields such as data classification, volume reconstruction, image segmentation, multiphase flow, and biological transport networks, and dendritic crystal growth. To describe more natural and complex dynamics, we consider the thermodynamical conductivity into the Allen-Cahn equation with the general polynomial free energy. The conductivities are chosen based on the Fick's law, Werde's law, and Chapman's law, which are based on the thermodynamics. Some properties of the governing equation are analyzed based on the modified Ginzburg-Landau energy. To numerically solve the proposed governing equation, we construct a numerical scheme based on the linear stabilized splitting scheme which treats the nonlinear term explicitly and the linear term as implicitly. It is an efficient, unconditionally energy-stable, and property-preserving scheme. We numerically analyze and simulate some properties of the proposed numerical scheme in one-, two-, and three-dimensional spaces.

Pointwise well-posedness results for degenerate $It^{\wedge\{o\}}$ -SDEs with locally bounded drifts

Schedule: July 6 14:30-14:50 Room 635

Haesung Lee

Department of Mathematics and Big Data Science, Kumoh National Institute of Technology, Korea

Co-Author(s): Gerald Trutnau

Abstract:

In this talk, we study the well-posedness of degenerate $It^{\wedge\{o\}}$ -SDEs in Euclidean space for $d \geq 2$ with possibly discontinuous diffusion coefficients. Building on recent analytic results on the construction of semigroups associated with degenerate partial differential operators, we also obtain a pointwise analysis of the corresponding degenerate $It^{\wedge\{o\}}$ -SDEs for every starting point. Our main result is weak well-posedness, namely weak existence and uniqueness in law, for every starting point within the class of solutions that spend zero time on the degeneracy set of the diffusion coefficient. The proof relies on semigroup methods together with elliptic and parabolic regularity theory, and Krylov type estimates.

Ground state solutions for elliptic equations involving the biharmonic operator

Schedule: July 7 18:30-18:50 Room 635

Yony Raul S Leuyacc

Universidad Nacional Mayor de San Marcos, Peru

Abstract:

We study the existence of ground state solutions for nonlinear elliptic equations involving the biharmonic operator of the form

$$\Delta^2 u \pm \Delta_p u = f(x, u) \quad \text{in } \Omega,$$

where $\Omega \subset \mathbb{R}^N$ is a smooth domain, Δ^2 denotes the biharmonic operator and Δ_p is the p -Laplacian. The nonlinear term $f(x, u)$ may exhibit logarithmic, critical Sobolev, or exponential growth, leading to serious compactness difficulties. The problems considered include Kirchhoff--Boussinesq type equations arising in models of elastic plates and higher-order diffusion phenomena. By means of variational methods, in particular the Nehari manifold and the mountain pass theorem, we establish the existence of nontrivial ground state solutions under suitable assumptions on the nonlinearities. The results highlight the influence of higher-order operators and critical growth on the qualitative behavior of solutions.

Asymptotic behaviour and existence of positive solutions for mixed local nonlocal elliptic equations with Hardy potential

Schedule: July 6 17:30-17:50 Room 635

Shammi Malhotra

Indian Institute of Technology Delhi, India

Co-Author(s): Sarika Goyal and K. Sreenadh

Abstract:

We investigate the existence and multiplicity of positive solutions to the following critical exponent problem driven by the superposition of the Laplacian and the fractional Laplacian with Hardy potential

$$-\Delta u + (-\Delta)^s u - \mu \frac{u}{|x|^2} = \lambda |u|^{p-2} u + |u|^{2^*-2} u \quad \text{in } \Omega \subset \mathbb{R}^N, \quad u = 0 \quad \text{in } \mathbb{R}^N \setminus \Omega, \quad \text{right.} \quad \text{end{equation*}}$$

where $\Omega \subset \mathbb{R}^N$ is a bounded domain with smooth boundary, $0 < s < 1$, $1 < p < 2^*$, with $2^* = \frac{2N}{N-2s}$, $\lambda > 0$, and $\mu \in (0, \bar{\mu})$ where $\bar{\mu} = \left(\frac{N-2s}{2}\right)^2$. The aim of the talk is twofold. First, we establish uniform asymptotic estimates for solutions of the problem by means of a suitable transformation. Then, according to the value of the exponent p , we analyze three distinct cases and prove the existence of a positive solution. Moreover, in the sublinear regime $1 < p < 2$, we demonstrate the existence of multiple positive solutions for small perturbations of the fractional Laplacian.

A heterogeneous nonlocal advection--diffusion equation

Schedule: July 8 9:40-10:00 Room 635

Joseph McCusker

University of Birmingham, England

Co-Author(s): Joseph McCusker, John Christopher Meyer, Mabel Lizzy Rajendran

Abstract:

An investigation is presented on the global boundedness for a system of nonlocal advection--diffusion equations which models a heterogeneous population over R^d , $d \in N$. For each nonlocal advection of species i according to the distribution of species j , the corresponding convolution kernel K_{ij} is assumed to have its own regularity $\nabla K_{ij} \in L^{q_{ij}}(R^d)$, $1 < q_{ij} < \infty$. The first a global bound is established using a Nash-type inequality to bound an energy functional. Using a graph-theoretic argument, it is then shown that the energy bound holds when the q_{ij} values have geometric mean above d along every index cycle of the form $i_1 \rightarrow \cdots i_n \rightarrow i_1$ for any $1 \leq n \leq N$. Alternatively, a sufficient smallness condition on the initial data is obtained by establishing an invariant set of the ratios between the L^{p_i} norm and the mass of each species i via a differential inequality.

Optimal L2 error quadratic serendipity finite volume element methods for diffusion equations on polygonal meshes

Schedule: July 7 9:00-9:20 Room 635

Shuai Miao

School of Mathematics and Statistics at Xi'an Jiaotong University, Peoples Rep of China

Co-Author(s): Yanlong Zhang

Abstract:

This paper proposes a locally conservative corrected quadratic serendipity finite element solution for the diffusion equation on arbitrary convex polygonal meshes based on generalized barycentric coordinates. The construction of the solution is divided into two steps. First, a quadratic serendipity finite element scheme for the diffusion equation on polygonal meshes is constructed, and the finite element solution is obtained. Second, based on the finite element solution, a finite volume element scheme is derived by adding specially constructed bubble functions. Theoretically, it is proven that the resulting solution not only satisfies the most classical conservation properties of the finite volume element schemes but also achieves a theoretical analysis comparable to that of the finite element methods. To the best of our knowledge, this is the first locally conservative corrected quadratic serendipity finite element solution on polygonal meshes that is unconditionally stable and has optimal L^2 and H^1 errors. Finally, the theoretical analysis is validated through several typical numerical examples and compared with several existing finite volume element schemes.

Nonlinear Schrödinger Equation for Electron Plasma (Langmuir) Waves in a Two--Electron-Fluid Plasma Model

Schedule: July 9 14:50-15:10

Ruba Murhaf

Khalifa University, United Arab Emirates

Co-Author(s): Kuldeep Singh, Ioannis Kourakis

Abstract:

Electrostatic solitary waves in plasma have long been studied using nonlinear fluid models, bridging plasma dynamics to soliton theory, including the nonlinear Schrödinger framework for envelope solitons (breathers, freak waves) [1--3]. In this study, we investigate the nonlinear modulation of electron plasma (Langmuir) waves in an unmagnetized plasma consisting of stationary positive ions and two inertial electron populations ('cool' and 'hot'), each subject to adiabatic thermal pressure. Starting from a multi-fluid/Poisson model, the governing equations are reduced to a nonlinear Schrödinger equation (NLSE) governing the slow envelope evolution [1--2], via a (Nayfeh/Newell type) multiple scales perturbation technique. Our analysis reveals a two-fold behavior: an electron-acoustic and an optic-like (Langmuir) mode coexist; this work focuses on the latter exclusively. Explicit analytical expressions are obtained for the dispersion and nonlinearity coefficients, P and Q , depending on the hot-to-cool equilibrium density ratio δ , the cool-to-hot temperature ratio θ , and the carrier wavenumber k . Focusing ($PQ > 0$) and defocusing ($PQ < 0$) regimes are identified, separated by a critical wavenumber $k_{cr}(\delta, \theta)$. A detailed parametric analysis reveals that increasing δ enhances nonlinear focusing, whereas increasing θ suppresses it. In the focusing regime, bright envelope solitons, breathers, and Peregrine-type rogue wave solutions are obtained as freak wave prototypes [2, 3], while dark/grey envelope structures arise in the defocusing domain [4]. References [1] I. Kourakis and P.K. Shukla, *Nonlinear Processes in Geophysics*, 12(3), 407 (2005). [2] I.S. Elkamash, B. Reville, N. Lazarides, I. Kourakis, *Chaos, Solitons & Fractals*, 188, 115531 (2024). [3] G.P. Veldes, J. Borhanian, M. McKerr, V. Saxena, D.J. Frantzeskakis & I. Kourakis, *J. Optics*, 15, 064003 (2013). [4] R. Murhaf et al., in preparation.

Data-driven Identification of Linear Dynamics in the Quasi-geostrophic Zonal Channel

Schedule: July 8 15:30-15:50 Room 635

Elnaz E Naghibi

University of East London, England

Co-Author(s): Elnaz Naghibi, Sergey Karabasov

Abstract:

In this paper, simulations of the quasi-geostrophic zonal channel are analysed using the data-driven methods of Sparse Identification of Nonlinear Dynamics (SINDy) and Linear Regression. The shear-driven zonal channel is simulated by a stratified quasi-geostrophic model in an eddy-resolving turbulent regime with re-entry boundary conditions. The simulation results are compressed using the classic Proper Orthogonal Decomposition (POD) in the statistically stationary period, and the time dependent coefficients of the reduced-order model are selected based on their contributions in total kinetic and potential energy of the system. The selected temporal coefficients are next provided for the SINDy and Linear Regression codes to identify linear dynamics. Finally, the flow field is reconstructed using POD expansion with time coefficients predicted by SINDy and Linear Regression models and the results are compared with original simulations beyond the training window in terms of time-averaged cross-correlations.

Mixing for stochastic PDEs driven by spatially localized white-in-time noises

Schedule: July 8 9:00-9:20 Room 635

Tianyi Pan

New York University, Shanghai., Peoples Rep of China

Co-Author(s): Vahagn Nersesyan, Xuhui Peng, Lihu Xu

Abstract:

We study the ergodicity of the three-dimensional stochastic Ginzburg--Landau (SCGL) equation on the torus driven by white-in-time noise that is highly degenerate in Fourier modes and spatially localized. Here spatially localized means that the noise acts only on a prescribed subdomain of the physical space. The proof combines the Malliavin calculus approach of Hairer and Mattingly and some tools from control theory.

Global multiplicity and Hopf-type comparison principle for singular problems driven by mixed local-nonlocal operators

Schedule: July 8 14:30-14:50 Room 635

Sarbani Pramanik

Indian Institute of Science Education and Research Thiruvananthapuram, India

Co-Author(s): R. Dhanya

Abstract:

We study a singular elliptic problem driven by a mixed local-nonlocal operator of the form
$$-\Delta_p u + (-\Delta_q)^s u = \frac{\lambda}{u^\delta} + u^r \text{ in } \Omega, u > 0 \text{ in } \Omega, u = 0 \text{ in } \mathbb{R}^N \setminus \Omega$$
 where $p > sq$, $0 < \delta < 1$ and $\lambda > 0$ is a parameter. The nonlinearity exhibits a singular power-type behavior near zero and displays at most a critical growth at infinity. We establish a global multiplicity result with respect to the parameter λ by identifying a sharp threshold that separates existence, non-existence, and multiplicity regimes. We also derive a Hopf-type strong comparison principle adapted to this nonlinear setting, which provides the main analytical tool for the global multiplicity result. Additionally, we establish qualitative properties of solutions that are crucial for the variational analysis, including a uniform L^∞ -estimate and a Sobolev versus H^1 -older local minimizer result. The analytical tools developed here are of independent interest and apply to a broader class of mixed local-nonlocal equations.

Mixed and augmented HOC schemes for biharmonic equations

Schedule: July 9 9:40-10:00 Room 635

Xu Qian

National University of Defense Technology, Peoples Rep of China

Co-Author(s): Jin Li

Abstract:

This report presents two novel high-order compact (HOC) schemes, a mixed HOC scheme and an augmented HOC scheme, for the numerical solution of two- and three-dimensional biharmonic equations under various boundary conditions. The proposed methods achieve high-order accuracy while maintaining computational efficiency. Extensive numerical experiments demonstrate their accuracy, robustness, and effectiveness.

Normalized solutions for fractional Choquard equation with critical growth on bounded domain

Schedule: July 8 17:30-17:50 Room 635

Asmita Rai

Indian Institute of Technology (BHU), Varanasi, India

Co-Author(s): Divya Goel

Abstract:

In this work, we study the multiplicity of positive solutions for a critical fractional Choquard equation with perturbation on a bounded star-shaped domain. The problem is given by $(-\Delta)^s u = \lambda u + \alpha |u|^{p-2} u + \left(\int_{\Omega} \frac{|u(y)|^{2^*}}{|x-y|^{2s}} dy \right) |u|^{2^*_{\mu,s}-2} u$ in Ω , with $u > 0$ in Ω , $u = 0$ in $\mathbb{R}^N \setminus \Omega$, and $\int_{\Omega} |u|^2 dx = d$. Using variational methods, we prove the existence of multiple solutions. In particular, a first solution is obtained via minimization on a suitable constraint set, while a second solution is derived using a uniform mountain pass theorem.

A theoretical analysis on the inversion of matrices via Neural Networks designed with Strassen algorithm

Schedule: July 9 9:00-9:20 Room 635

Gonzalo Romera

University of Basque Country, Spain

Abstract:

We construct a Neural Network that approximates matrix multiplication operator for any activation function such that there exists a Neural Network which can approximate the scalar multiplication function. In particular, we use the Strassen algorithm to bound the number of weights and layers needed for such Neural Networks. This allows us to define another Neural Network for approximating the inverse matrix operator. Finally, we discuss improvements with respect to the prior results. For the full statement of these results see: <https://arxiv.org/abs/2501.06539>. This talk is based on a joint work with Jon Asier B\`{a}rcena-P\`{e}tisco.

Reconstruction of a Source Term in a Hyperbolic Equation

Schedule: July 9 14:30-14:50

Daurenbek Serikbaev

Institute of Mathematics and Mathematical Modeling, Almaty, Kazakhstan

Abstract:

We consider the wave equation
$$u_{tt} - a(x)u_{xx} = f, \quad (t, x) \in (0, T) \times (0, l),$$
 with suitable initial and boundary conditions. Using an additional boundary measurement at $x = l$, we study the identification of an unknown source term f . The analysis is based on Carleman estimates for the wave operator; see [BY17]. Funding: This research is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP23485971).

$$\begin{matrix} \text{\textit{thebibliography}} \{6\} \\ \text{\textit{bibitem}}\{BY17\} \text{ M. Bellassoued, M. Yamamoto.} \\ \text{Carleman Estimates and Applications to Inverse Problems for Hyperbolic Systems, Springer, Cham, 2017.} \\ \text{\textit{end}}\{\text{\textit{thebibliography}}\} \end{matrix}$$

Propagation through a barrier: Numerical analysis of a reaction diffusion model with free boundary

Schedule: July 9 17:30-17:50

Narges Shabgard

University of New England, Australia

Abstract:

We investigate how a spatial barrier influences the spread of an invading species via numerical analysis of a free boundary model, which is known to exhibit successful spreading like a traveling wave in homogeneous environments with population growth described by either a bistable function (incorporating Allee effect) or a monostable function. The barrier is represented by a region where the environment becomes hostile. Our numerical simulations show that, there exists a critical barrier length and a critical level of hostility, so that below the critical values, the species can successfully spread across the barriers, otherwise, the invasion is blocked. We also incorporate temporal environmental variation by introducing periodic changes in the growth rate. The results indicate that stronger fluctuations tend to promote invasion, while slower temporal variation reduces the spreading ability. A comparison between the bistable and monostable cases shows that, the bistable case allows invasion across the barrier more easily, suggesting that the presence of an Allee effect may enhance the likelihood of successful spread.

Nonlocal reductions and solutions of the (2+1)-dimensional Hirota equations

Schedule: July 6 14:50-15:10 Room 635

Gaukhar Shaikhova

LN Gumilyov Eurasian National University, Kazakhstan

Abstract:

We present several integrable systems associated with nonlocal versions of the Hirota equations, which are important in the modeling of physical phenomena because they include both the nonlinear Schrödinger (NLS) equation and the complex modified Korteweg--de Vries (cmKdV) equation. The integrability of these models is established through the explicit construction of their Lax pairs, or equivalently, their zero-curvature representations. The nonlocal Hirota equations are derived within the AKNS scheme via Ablowitz--Musslimani type nonlocal reductions. In addition, by constructing the Darboux transformation for the systems under consideration, we obtain exact solutions in explicit form.

Data-Driven Predictive Control for 2D Systems

Schedule: July 6 17:50-18:10 Room 635

Nidhi Shukla

University of Southampton, UK; Indian Institute of Technology Roorkee, India, England

Co-Author(s): Dr. Paolo Rapisarda (University of Southampton, UK) and Dr. Jaydev Dabas (Indian Institute of Technology Roorkee, India)

Abstract:

We present preliminary ideas for a data-driven predictive control framework for linear quarter-plane causal (LQPC) 2D systems. These systems have doubly-indexed trajectories over Z^2 and are governed by partial difference equations in two independent shift operators. Instead of identifying a Roesser or Fornasini-Marchesini (FM) model, we exploit the 2D Fundamental Lemma for LQPC input-output systems. It guarantees that every N -unfolding of every trajectory is parameterized by a single sufficiently informative data matrix, providing the two-dimensional analog of Willems' persistency-of-excitation condition. The classical model predictive control framework solves constrained quadratic programs with a moving horizon using an explicit mathematical model. Our approach retains many of the advantages of this framework, such as the receding-horizon structure, the enforcement of input-output constraints, and the feedback mechanism via boundary-condition updates. However, instead of using a model, we utilize a single informative input-output trajectory measured from the system. We parametrize admissible predictions through the basis matrix of system unfoldings. We provide some numerical examples to validate our proposed framework and suggest directions for future research.

On attractors for evolution problems with variable exponents

Schedule: July 7 9:20-9:40 Room 635

Jacson Simsen

Institute of Mathematics and Computing, Federal University of Itajubá, Brazil, Brazil

Co-Author(s): Jacson Simsen

Abstract:

In this talk I shall give an overview on the progresses in the last sixteen years about results on existence of global and pullback attractors for Partial Differential Equations and Inclusions with variable exponents.

Positivity-preserving finite volume schemes for radiation diffusion equations on general meshes

Schedule: July 7 14:50-15:10 Room 635

Shuai Su

Beijing University of Technology, Peoples Rep of China

Abstract:

Radiation diffusion equations arise in a wide range of physical applications such as astrophysics and inertial confinement fusion. Two key ingredients in constructing their numerical schemes are both positivity-preserving property and good accuracy for discontinuous and/or anisotropic problems on arbitrary distorted meshes. This talk will introduce our recent research progress including positivity-preserving finite volume schemes, theoretical analysis, and numerical applications.

Isometric Study of Wasserstein Spaces- Bounded Intervals

Schedule: July 7 17:50-18:10 Room 635

Chuanlong Sun

Southeast University, Peoples Rep of China

Co-Author(s): Sun Chuanlong and Huang Tiren

Abstract:

The isometric rigidity of Wasserstein spaces and PDEs are inherently interconnected through the optimal transport theory, with the Monge-Ampère equation serving as the core link. In this talk, based on the work of Geher, Titkos, and Virosztek, we extend their rigidity results on $[0,1] \rightarrow [0,1]$ to different bounded intervals. Particularly, we give the characterization of isometries of $p = 1$ and $p > 1$, and we find the exotic isometries for $p = 1$.

Stabilization of damped and viscoelastic linear wave equations exposed to external Neumann manipulation

Schedule: July 8 9:20-9:40 Room 635

Idem Susuzlu

Izmir Institute of Technology, Turkey

Abstract:

In this talk, we analyze the stabilization of damped and viscoelastic linear wave equations evolving on a bounded domain, subject to an inhomogeneous Neumann manipulation on a portion of the domain's boundary. Compared to their homogeneous counterparts, these models present additional features and challenges. This is due to the fact that, in the present context, the rate at which the energy of the solutions changes depends directly on the boundary trace of the temporal derivative. Due to regularity issues, it is not clear in advance how these quantities should be controlled based on the given data. However, we establish global existence and prove the uniform stabilization of solutions, with decay rates characterized by the Neumann input. We support our theoretical results with numerical simulations satisfying the given assumptions. We supplement these with additional simulations in which the data do not necessarily satisfy the required assumptions for decay. The latter offer essential physical insights into how energy might change in the presence of improper boundary data.

Modeling the Dispersion of Taal Volcanic Ash Using the Advection-Diffusion Equation

Schedule: July 8 14:50-15:10 Room 635

Arriane Crystal Velasco

Institute of Mathematics, University of the Philippines Diliman, Philippines

Co-Author(s): Renier G. Mendoza, Rhudaina Z.Mohammad, Ken Matthew C. Oliva

Abstract:

The Taal Volcano underwent a phreatic eruption on January 12, 2020, causing volcanic ashfall that affected adjacent regions. To ensure public safety and minimize damage, rapid and data-driven decisions are required during volcanic eruptions to anticipate the movement of volcanic ash. In this work, we simulate volcanic ash dispersion during the 2020 Taal Volcano eruption using an atmospheric dispersion model governed by a second-order parabolic partial differential equation derived from the law of conservation of mass. To obtain numerical solutions, we apply the finite difference method and present several case scenarios. Moreover, we estimate the diffusion rate using three approaches. The first approach is based on multiple observations and simulations, where the diffusion coefficient is varied across simulations. The second approach fits the numerical solution of the governing equation to observational data collected during the eruption using the least squares method. The third approach estimates the diffusion rate using the brightness temperature of the eruption. The estimated diffusion rate provides information on the spatial extent and potential trajectory of volcanic ash dispersion, which is essential for risk assessment and disaster management.

Controllability Criteria for Semilinear Measure Driven Evolution Systems with Impulses and Nonlocal Inclusions

Schedule: July 9 9:20-9:40 Room 635

Akhilesh Verma

Indian Institute of Technology Roorkee, India, India

Co-Author(s): Jaydev Dabas

Abstract:

This paper investigates the nonlocal controllability of semilinear measure driven evolution systems with impulsive effects and multivalued nonlocal inclusions in Banach spaces. The analysis is carried out in the Banach space of regulated functions, which naturally accommodates the discontinuities generated by impulsive phenomena and measure driven dynamics. By employing the Hausdorff measure of noncompactness together with a Monch-type fixed point theorem, sufficient conditions for nonlocal controllability are established. The proposed approach avoids compactness assumptions on the evolution family that are typically required in classical controllability results for semilinear evolution systems. The obtained criteria describe the interaction among the evolution operator, the control operator, the measure driven nonlinear term, and the nonlocal inclusion. Finally, an impulsive partial differential equation is presented to illustrate the applicability of the theoretical results, and a finite-dimensional numerical example is provided to visualize the impulsive and measure driven dynamics.

AE-ViT: Stable Long-Horizon Prediction of Parametric PDE Solution

Schedule: July 7 14:30-14:50 Room 635

Domagoj Vlah

University of Zagreb Faculty of Electrical Engineering and Computing, Croatia

Co-Author(s): Iva Mikuš and Boris Muha

Abstract:

We study deep-learning surrogates for time-dependent parametric PDEs in an autoregressive rollout setting, where long-horizon accuracy is limited by error accumulation. We propose a parameter-aware encoder-transformer-decoder architecture AE-ViT: a fully convolutional encoder compresses each snapshot to a latent tensor, a vision transformer advances it in time, and a decoder reconstructs the fields. PDE parameters are injected at multiple stages via FiLM-type modulations and a parameter token, and spatial information is provided through coordinate channels. Training uses short-window scheduled sampling to mitigate exposure bias. On a parametric advection-diffusion-reaction benchmark and on 2D Navier-Stokes flow past a cylinder for joint velocity-pressure prediction, we obtain improved rollout accuracy over latent-vector ROM baselines and plain full-field transformer models, with fewer trainable parameters.

An existence result for the two-phase two-component flow in porous media

Schedule: July 9 17:50-18:10

Anja Vrbaski

University of Zagreb, Croatia

Co-Author(s): Ana Zgaljic Keko

Abstract:

We consider an initial-boundary value problem for a system of nonlinear partial differential equations that describes two-phase, two-component fluid flow in porous media. The system equations are obtained from the mass conservation law written for each component. For main unknowns we select persistent variables, capable of modelling the flow in both the two-phase flow and the one-phase flow regions. We use an artificial persistent variable called global pressure to rewrite the system in terms of global pressure and gas phase pseudo-pressure. As the obtained system contains degeneracy, we regularize it by a small parameter η . Furthermore, we apply time discretization, and introduce another persistent variable, called capillary pseudo-pressure. The global pressure partially decouples equations and we are able to obtain the existence of solution at discrete time level. By passing to the limit in the time discretization parameter and afterwards in regularization parameter η , we prove the existence of weak solutions of the introduced initial-boundary value problem.

Regularity of solutions to degenerate normalized p -Laplacian equation with general variable exponents

Schedule: July 6 15:10-15:30 Room 635

Jiangwen Wang

School of Mathematics, Southeast University, Peoples Rep of China

Co-Author(s): Jiangwen Wang, Yunwen Yin, Feida Jiang

Abstract:

In this talk, we consider degenerate quasilinear elliptic models of normalized p -Laplacian type. We establish local $C^{1,\alpha'}$ regularity of viscosity solutions by making use of the compactness argument, scaling techniques and the localized oscillating method. In addition, we also obtain almost optimal pointwise $C^{1,\tau}$ regularity for degenerate free transmission problem related to normalized p -Laplacian. Our argument is based on a new improved oscillation-type estimate combined with a localized analysis.

Reducibility of quantum harmonic oscillators

Schedule: July 6 18:10-18:30 Room 635

Zhiqiang Wang

Anhui University, Peoples Rep of China

Co-Author(s): Emanuele Haus

Abstract:

Using the decay along the diagonal of the matrix representing the perturbation with respect to the Hermite basis, we prove a reducibility result in $L^2(\mathbb{R})$ for the one-dimensional quantum harmonic oscillator perturbed by time quasi-periodic potential, via a KAM iteration. The potential is only bounded (no decay at infinity is required) and its derivative with respect to the spatial variable x is allowed to grow at most like $|x|^\delta$ when x goes to infinity, where the power δ

On the inf-sup Degradation in Dense Microfluidic Arrays and a Robust Preconditioning Strategy for Stokes Flow

Schedule: July 7 15:10-15:30 Room 635

Qi Xin

The Chinese University of Hong Kong, Shenzhen, and SICIAM, SRIBD, Peoples Rep of China

Co-Author(s): Qi Xin, Shihua Gong

Abstract:

Simulating incompressible fluid dynamics in densely packed microfluidic devices, such as Deterministic Lateral Displacement (DLD) arrays, presents a significant computational challenge. As obstacle density increases, standard iterative solvers often experience severe performance degradation. In this report, we show that this difficulty is intrinsically linked to the pre-asymptotic degradation of the pressure-velocity coupling stability. By analyzing generalized obstacle arrays, we prove that the continuous inf-sup (LBB) constant deteriorates at an exact rate of $\Theta(m^{-1})$, where m represents the obstacle density. This geometric penalty mathematically explains the severe ill-conditioning observed in classical saddle-point solvers. Guided by this explicit scaling law, we establish a rigorous framework for mitigating the geometric ill-conditioning. Numerical experiments on both standard and highly asymmetric micro-pillar arrays are conducted to validate the theoretical analysis and evaluate the performance of various preconditioning strategies. The results demonstrate that solvers properly adapted to the exact pre-asymptotic limits can achieve robust, density-independent convergence, successfully tackling highly ill-conditioned systems approaching millions of degrees of freedom. This provides a reliable computational foundation for complex microfluidic simulations.

On the inf-sup Degradation in Dense Microfluidic Arrays and a Robust Preconditioning Strategy for Stokes Flow

Schedule: July 7 18:10-18:30 Room 635

Qi Xin

The Chinese University of Hong Kong, Shenzhen, and SICIAM, SRIBD, Peoples Rep of China

Co-Author(s): Qi Xin, Shihua Gong

Abstract:

Simulating incompressible fluid dynamics in densely packed microfluidic devices, such as Deterministic Lateral Displacement (DLD) arrays, presents a significant computational challenge. As obstacle density increases, standard iterative solvers often experience severe performance degradation. In this report, we show that this difficulty is intrinsically linked to the pre-asymptotic degradation of the pressure-velocity coupling stability. By analyzing generalized obstacle arrays, we prove that the continuous inf-sup (LBB) constant deteriorates at an exact rate of $\Theta(m^{-1})$, where m represents the obstacle density. This geometric penalty mathematically explains the severe ill-conditioning observed in classical saddle-point solvers. Guided by this explicit scaling law, we establish a rigorous framework for mitigating the geometric ill-conditioning. Numerical experiments on both standard and highly asymmetric micro-pillar arrays are conducted to validate the theoretical analysis and evaluate the performance of various preconditioning strategies. The results demonstrate that solvers properly adapted to the exact pre-asymptotic limits can achieve robust, density-independent convergence, successfully tackling highly ill-conditioned systems approaching millions of degrees of freedom. This provides a reliable computational foundation for complex microfluidic simulations.

Beyond quantum mean-field approximation: Phase space formulation of many-body time-dependent density functional theory and efficient spectral approximations

Schedule: July 8 15:10-15:30 Room 635

Yunfeng Xiong

School of Mathematical Sciences, Beijing Normal University, Peoples Rep of China

Co-Author(s): Yunfeng Xiong

Abstract:

As a universal quantum mechanical approach to the dynamical many-body problem, the time-dependent density functional theory (TDDFT) might be inadequate to describe crucial observables that rely on two-body evolution behavior, like the double-excitation probability and two-body dynamic correlation. One promising remedy is to utilize the time-dependent 2-reduced density matrix (2-RDM) that directly represents two-body observables in an N-particle system. However, the usage of 2-RDM is prohibitive due to the augmented dimensionality. This work addresses the high-dimensional numerical challenges by using an equivalent Wigner phase-space formulation of 2-RDM and seeking efficient spectral approximations to nonlocal quantum potentials. For spatial periodic case, a pseudo-difference operator approach is derived for both the Hartree-exchange-correlation term and two-body collision operator, while the discretization via the Chebyshev spectral element method is provided for non-periodic case. A massively parallel numerical scheme, which integrates these spectral approximations with a distributed characteristics method, allows us to make the first attempt for real simulations of 2-RDM dynamics. Numerical experiments demonstrate the two-body correction to the quantum kinetic theory, and show the increase in the system's entropy induced by the two-body interaction. This may pave the way for an accurate description of 2-RDM dynamics and a practical application of many-body TDDFT.

Spreading speeds of almost periodic KPP equations with slow decay initial values

Schedule: July 9 15:10-15:30

Linfeng Xu

University of Science and Technology of China, Peoples Rep of China

Co-Author(s): Xing Liang, Tao Zhou

Abstract:

This talk is concerned with the long-time behavior of the Fisher-KPP equations with slowly decaying initial data in an almost periodic medium. We mainly focus on two types of initial conditions: those exhibiting exponentially decaying and those decaying more slowly than any exponentially functions. Employing the homogenization method and Hamilton-Jacobi approach, we provide a unified framework to analyze the initial value problems for both cases. We demonstrate that the level sets of the solution can be characterized by the generalized principal eigenvalues of the linearized operator and the behavior of the initial data at infinity only.

A hybrid ROM-FOM framework for efficient solution of elliptic PDE inverse problems

Schedule: July 9 18:10-18:30

Yidan Yang

Xiamen University, Peoples Rep of China

Co-Author(s): Basca Jadamba, Yixue Zheng, Chuanju Xu

Abstract:

In this work, we consider the classic elliptic PDE's coefficient inverse problem in which repeated forward and adjoint solves incur substantial computational cost during iterative inversion. To address this challenge, we propose a hybrid reduced-full order modeling (ROM-FOM) framework that combines proper orthogonal decomposition (POD) with selective full-order corrections. The proposed approach employs a POD-based reduced-order model to approximate both state and adjoint solutions within a gradient-based framework. To enhance robustness, a warm-start full-order solve is introduced in the early iterations, stabilizing updates and limiting error accumulation. In the theoretical analysis, we investigate the consistency of the ROM formulation and how errors propagate through the state, adjoint, and gradient computations. We also demonstrate numerical results to show how the proposed method achieves a balance between efficiency and accuracy. This framework provides a practical and extensible approach for large-scale PDE-constrained inverse problems and can be extended to time-dependent settings.

Normalized solutions for the planar Schrödinger-Poisson system

Schedule: July 6 15:30-15:50 Room 635

Xiangjian Zeng

Institute of Mathematics of Polish Academy of Science, Poland

Co-Author(s): Baihong Li and Yuanhong Wei

Abstract:

I present the recent result on the normalized solutions for the planar Schrödinger-Poisson system with a two-electron interaction, which models the effect between electrons and the electrostatic potential they generate. As the parameters vary, some existence results are established. Specifically, a ground state solution is obtained for some general cases. The existence of two solutions is established for the mass-supercritical case, one of which is a ground state solution and the other one is an excited state solution. We develop a compactness method to deal with the functionals involving logarithmic convolution terms. The Pohořálek identity for the coupled Schrödinger-Poisson system with a logarithmic convolution term is also shown, which is crucial for addressing the mass-supercritical problem.

Accelerated gentlest ascent dynamics for computing excited states of Bose-Einstein condensates

Schedule: July 7 15:30-15:50 Room 635

Fu Zheng

National University of Defense Technology, Peoples Rep of China

Abstract:

We present an accelerated variant of the constrained gentlest ascent dynamics (CGAD) for computing excited states of Bose-Einstein condensates within Gross-Pitaevskii theory. The traditional CGAD method, which is derived from the L^2 -gradient flow, often converges slowly near the target constrained saddle points corresponding to excited states. By incorporating Sobolev gradients and inertial dynamics, the proposed method significantly improves the convergence rate. Numerical examples demonstrate the efficiency of the accelerated dynamics and show interesting excited states.

Contributed Session 3 : Modeling, Math Biology and Math Finance

Introduction:

Modelling Lipid Raft-Receptor Interactions in Wnt Morphogen Signalling via a Bulk-Surface PDE Framework

Schedule: July 7 8:00-8:20 Room 634

Tarek Acila

University of Warwick, England

Co-Author(s): Tarek Acila

Abstract:

We propose a thermodynamically consistent bulk-surface PDE framework modelling the cell-membrane-level dynamics of the canonical Wnt signalling pathway, a key regulator of cell fate and tissue development. Lipid rafts serve as essential organising platforms for receptor phosphorylation and signalosome formation in this pathway, yet to our knowledge their role has not been captured in a continuum PDE framework. The model couples a surface Cahn-Hilliard system for lipid membrane composition to a cross-diffusive reaction-diffusion system for membrane-bound receptor states, with bulk diffusion of Wnt morphogen and intracellular receptors linked to the surface via Robin-type boundary conditions. All transport laws are derived from a free energy functional via Onsager's Variational Principle, with Flory-Huggins mixing entropies capturing receptor crowding and volume-filling constraints, raft affinity, receptor clustering, and raft-dependent phosphorylation and internalisation within a unified thermodynamic framework. A fast bulk-diffusion reduction yields a nonlocal surface system, decoupling cell-membrane pattern formation from bulk spatial heterogeneity. The discretisation employs an IMEX scheme based on surface finite elements with adaptive mesh refinement. We present simulation results on the sphere exploring raft-driven receptor clustering, signalosome formation, and the role of cell-membrane organisation in regulating spatial signalling patterns.

Mathematical Modeling and Numerical Simulation of Multicomponent Membrane Gas Separation for Industrial Applications

Schedule: July 8 15:10-15:30 Room 634

Muhammad Ahsan

National University of Sciences and Technology, Islamabad, Pakistan

Abstract:

Membrane gas separation is an energy-efficient and environmentally friendly technology for industrial gas purification and recovery. Accurate mathematical modeling is essential for predicting separation performance and optimizing process design. In this study, a mathematical model is developed for multicomponent membrane gas separation, describing the transport of gas mixtures through selective membranes under co-current flow conditions. Mass balance equations and permeation relations form the basis of the model. Numerical techniques are employed to solve the resulting system of nonlinear differential equations and simulate separation behavior. The model is applied to evaluate membrane unit performance for the separation of gases such as hydrogen and carbon dioxide from industrial gas streams. Effects of operating parameters, including feed composition, pressure difference, and membrane selectivity, on the purity and recovery of target components are investigated. Simulation results show good agreement with experimental and literature data, demonstrating the model's capability to reliably predict performance. This approach provides a useful tool for analyzing, designing, and optimizing membrane-based gas separation processes in the chemical and energy industries.

Symmetry breaking induced by filament repulsion in a reduced lamellipodium model

Schedule: July 7 13:30-13:50 Room 634

Gervy Marie Angeles

Institute of Mathematics, University of the Philippines Diliman, Philippines

Co-Author(s): Jared Barber, Christian Schmeiser

Abstract:

The Filament Based Lamellipodium Model (FBLM) describes actin-driven cell motility but is analytically intractable in its full form. We investigate a strongly simplified filament ensemble model that isolates the mechanical effect of Coulomb-type repulsion between neighboring actin filaments. Filaments are modeled as rigid rods sliding on a flat substrate under friction, inward confining forces, and an auxiliary tension that counteracts longitudinal destabilization caused by repulsion. Starting from a microscopic description, we derive a nonlinear continuum model in the form of a coupled system of parabolic partial differential equations for filament orientations and centers of mass. The system is rotationally symmetric and admits a one-parameter family of trivial steady states. A linear stability analysis identifies a critical value of a dimensionless parameter at which these steady states lose stability. A formal bifurcation analysis shows that the instability leads to a pitchfork bifurcation, which can be either supercritical or subcritical depending on parameter values. The bifurcating solutions correspond to deformed filament configurations that generate collective motion with constant velocity. Numerical simulations of the time-dependent problem support the analytical results and reveal additional nonlinear dynamics. Ref: A. Manhart, D. Oelz, C. Schmeiser, and N. Sfakianakis, An extended Filament Based Lamellipodium Model produces various moving cell shapes in the presence of chemotactic signals, *Journal of Theoretical Biology*, 382 (2015), 244--258.

Information-Theoretic Analysis of Hybrid Machine Learning Models for Financial Time Series in Complex Systems

Schedule: July 8 13:30-13:50 Room 634

Luckshay Batra

BML Munjal University, India

Co-Author(s): Ruchika Lochab

Abstract:

This study proposes an information-theoretic framework for analyzing hybrid machine learning models applied to financial time series within complex systems. The approach integrates Autoregressive Integrated Moving Average (ARIMA), Holt-Winters, and Long Short-Term Memory (LSTM) models, whose forecasts are combined using Extreme Gradient Boosting (XGBoost) as a meta-learner. This hybrid architecture captures linear, seasonal, and nonlinear dynamics inherent in financial data. A key contribution lies in the use of Kullback-Leibler divergence as an information-theoretic measure to quantify the discrepancy between predicted and observed distributions. Unlike conventional error-based metrics, this approach provides deeper insight into uncertainty and distributional characteristics of model predictions. The framework is applied to long-term financial time series, including major stock indices such as NIFTY 50, Dow Jones Industrial Average, and S&P BSE SENSEX. Empirical results demonstrate that the hybrid model achieves improved predictive performance and reduced distributional divergence compared to individual models. The proposed methodology highlights the potential of combining ensemble learning with information-theoretic measures for uncertainty-aware forecasting and offers a generalizable approach for scientific machine learning in complex dynamical systems.

A Systematic Framework for Inferring Stochastic Dynamics from Data

Schedule: July 8 16:30-16:50 Room 634

Katarina Bodova

Comenius University, Slovak Rep

Co-Author(s): Richard Kollar

Abstract:

Recent advances in experimental biology provide time-resolved datasets that capture key features of complex dynamical systems. Recovering the underlying interactions from such data is a nontrivial inverse problem, especially when one must disentangle deterministic dynamics, intrinsic fluctuations, and measurement noise from limited observations. We build on the inference framework introduced by Bruckner et al. (2020), which is designed to operate in the moderate-data regime. Our main contribution is to replace the heuristic choices in the original derivation by a controlled expansion of the inference error. This leads to more accurate approximations, identifies the relevant small parameters, and makes the associated validity conditions explicit. The result is an efficient and broadly applicable framework for inferring stochastic dynamics from limited, sparsely sampled data.

Limit theorems for stochastic Volterra processes

Schedule: July 9 8:00-8:20 Room 634

Ole Cañadas

Dublin City University, Ireland

Co-Author(s): Luigi Amedeo Bianchi, Stefano Bonaccorsi, Martin Friesen

Abstract:

We introduce an abstract Hilbert space-valued framework of Markovian lifts for stochastic Volterra equations with operator-valued Volterra kernels. Our main results address the existence and characterisation of possibly multiple limit distributions and stationary processes, a law of large numbers including a convergence rate, and the central limit theorem for time averages of the process within the Gaussian domain of attraction. As particular examples, we study Markovian lifts based on Laplace transforms in a weighted Hilbert space of densities and Markovian lifts based on the shift semigroup on the Filipovič space. We illustrate our results for the case of fractional stochastic Volterra equations with additive or multiplicative Gaussian noise. For more details, see arXiv:2509.08466.

A Dynamic SIR Epidemic Model with Taylor Collocation Method: Analysis of Transmission Dynamics Under Intervention Changes

Schedule: July 9 16:30-16:50 Room 634

Elcin Celik

Izmir Institute of Technology, Turkey

Co-Author(s): Serpil Unal, Deniz Ucar

Abstract:

The aim of the study is to predict how the spread model of the COVID-19 epidemic behaves in line with government interventions and to observe how a change in interventions affects the course of the epidemic. For this purpose, in our study we focus on a dynamic SIR model in which the recovery rate γ is fixed at $1/15$, but the spread rate β depends on the interventions made rather than being constant. With the Kruskal Wallis test, we can say with %95 confidence that the differences in the estimated spreading rates were due to these interventions. Moreover, with the Dunn's test, it was obtained that there were significant differences between full closure and partial closure, as well as between full closure and gradual normalization, with %99 confidence. This also shows that there is a significant difference in the number of cases that may occur with full closure compared to the number of cases after partial closure and gradual normalization.

On the Fitness of Nonlinear Diffusion in Competitive Systems Incorporating Perceptual Constraints

Schedule: July 7 8:20-8:40 Room 634

Youngseok Chang

Korea University, Korea

Co-Author(s): Inkyung Ahn, Wonhyung Choi

Abstract:

This work investigates a Lotka-Volterra type competition model with nonlinear dispersal, which we refer to as starvation-driven-type diffusion (SDTD). It is well-known that, in a spatially heterogeneous environments, rapid diffusion can be disadvantageous for species survival in classical Lotka-Volterra competitive systems [Dockery et al., (1998)]. Additionally, species exhibiting starvation-driven diffusion (SDD), where diffusion depends on the ratio of population density to resource distribution, can achieve higher fitness compared to those with linear diffusion [Kim et al., (2013)]. In this study, we integrate perceptual constraints into the SDD diffusion mechanism, which is referred to as SDTD, and analyze population fitness based on perception. We also discuss the presence of the coexistence states.

Mimicking Brownian martingales

Schedule: July 7 13:50-14:10 Room 634

Huan Chen

Monash University, Australia

Co-Author(s): Huan Chen, Kais Hamza, JieYen Fan, and Fima Klebaner.

Abstract:

We are interested in constructing new martingales that share the same marginal distributions as an existing martingale. The new martingales, known as mimics of the original martingale, preserve the prices of European vanilla options but might have different properties. In this talk, I will review some previous results on martingales mimicking and discuss martingales formed by functions of Brownian motions that admit a universal mimicking property. Specifically, we identify those martingales for which, with essentially any deterministic time change, the resulting time-space-transformed process remains a martingale and preserves the one-dimensional marginal distributions. Joint work with Kais Hamza, JieYen Fan, and Fima Klebaner.

Training AI Models to Predict Permeability of Porous Media

Schedule: July 8 13:50-14:10 Room 634

Ebru N Dagdelen

New Jersey Institute of Technology, USA

Co-Author(s): Ebru Dagdelen, Aakash Karlekar, Manav Arora, Catherin Neena Lalu, Matthew Illingworth, Jonathan Jaquette, Linda Cummings, Lou Kondic

Abstract:

Fluid flow through porous media is critical in many industrial and natural processes, such as oil recovery and groundwater filtration. Permeability is a widely-used measure of how easily fluid flows through a porous medium, so developing fast and accurate methods to estimate it is important. In this project we investigate whether machine learning (ML) models informed by geometric, topological, and network-based descriptors can accurately predict permeability. We generate synthetic 3D porous structures using PuMA software and compute their permeability using flow simulations, from which we extract structural descriptors and two-point correlation functions. We also reduce the 3D datasets to pore-scale network representations using PoreSpy, and we utilize computational tools from topological data analysis to calculate topological measures of the porous structures. The combined set of descriptors is used to train ML models for permeability prediction. Our results show that ML models trained on this combination of features are able to predict permeability with high accuracy. In particular, models that include topological information consistently perform better than those using geometric or network data alone. These findings suggest that topological features can serve as effective descriptors for fluid flow in porous media.

Prescribed performance projective synchronization for unknown complex networks with mismatched dimensions via event-triggered mechanism

Schedule: July 9 8:20-8:40 Room 634

Aili Fan

Northwestern Polytechnical University, Peoples Rep of China

Co-Author(s): Aili Fan Lin Du Honghui Zhang Shuo Zhang Dona Ariani

Abstract:

In this article, we mainly address the function matrix projective synchronization (FMPS) problem with prescribed performance (PP) between a drive network (DN) with time-varying uncertain coupling, and its corresponding response network (RN) with mismatched dimensions. A new hybrid adaptive learning law is proposed, which consists of a discrete adaptive law designed for unknown time-varying coupling coefficients, and a continuous adaptive law designed for time-invariant coefficients. The proposed work extends the adaptive synchronization control that is originally applicable only with the constant coupling coefficient to the case where the coefficients are time-varying. To ensure the state trajectories of the RN are projectively synchronized to those of the DN while complying with PP constraints, a PP controller is designed. Meanwhile, to reduce the communication load, the event-triggered communication (ETC) mechanism is implemented. Finally, the effectiveness of the designed.

Long-time numerical approximations for stiff ODEs on semi-infinite intervals

Schedule: July 9 16:50-17:10 Room 634

Chengming Huang

Huazhong University of Science and Technology, Peoples Rep of China

Abstract:

Stiff ordinary differential equations play an important role in mathematical modeling of many biological, physical and chemical phenomena. In this talk, we consider the numerical simulation of stiff initial value problems on semi-infinite intervals. For a class of Runge-Kutta methods applied to strictly dissipative systems, a long-time convergence result on semi-infinite time intervals is obtained, in which the error bounds of the numerical methods are independent of the length of the integration interval. Applications of our results to some classes of high-order implicit Runge-Kutta methods are provided, and numerical experiments are also presented to confirm the theoretical results.

A Mathematical Model for Measles Transmission Dynamics Based on Real Data from Turkey

Schedule: July 7 8:40-9:00 Room 634

Osman R Isik

Mugla Sitki Kocman University, Turkey

Co-Author(s): Egemen Kaya

Abstract:

Measles is a highly contagious disease despite the availability of an effective vaccine. In this study, we develop a deterministic compartmental model to analyze measles transmission dynamics in Turkey, incorporating infection among vaccinated individuals. The structural identifiability of the model is examined. Model parameters are estimated using measles case data in Turkey from 1970 to 2023, with key parameters assumed to be time-dependent due to changes in vaccination and immigration rates. A practical identifiability analysis has also been conducted for the model. The basic reproduction number is calculated, indicating persistent disease dynamics. Numerical results emphasize the critical role of vaccination in controlling measles spread.

Investigating the Transmission Dynamics of HIV/AIDS in Europe

Schedule: July 7 14:10-14:30 Room 634

Osman R Isik

Mugla Sitki Kocman University, Turkey

Co-Author(s): Melissa Nur Yilmaz

Abstract:

Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS) continue to be a significant public health concern despite advances in antiretroviral therapies. Understanding the transmission dynamics of HIV infection is crucial for the development of effective control strategies. In this study, a five compartment deterministic model is proposed to investigate the spread of HIV/AIDS using epidemiological data from Europe. Structural and practical identifiability analyses are performed to evaluate the reliability of parameter estimation in the model. Structural identifiability is assessed using the SIAN (Structural Identifiability Analyser) method, which classifies parameters as globally identifiable, locally identifiable, or non-identifiable, while practical identifiability is evaluated through Monte Carlo simulations and the Average Relative Error (ARE). The basic reproduction number, R_0 , is computed, and sensitivity analysis is conducted to examine the impact of model parameters on disease transmission. The parameters of this non-autonomous model are estimated based on HIV/AIDS case data from Europe for the period 2000-2023. The results indicate that the appropriate selection of observable variables significantly improves parameter identifiability. In conclusion, the proposed model provides a reliable framework for analyzing the spread of HIV/AIDS and may contribute to epidemiological forecasting and the development of effective intervention strategies.

This study was supported by the Scientific Research Projects Coordination Unit of Mugla Sitki Kocman University through the project entitled ``Investigation of the Transmission Dynamics of HIV/AIDS in Europe`` (Project No. 25/48).

Can cooperative hunting increase predator vulnerability to habitat loss?

Schedule: July 8 14:10-14:30 Room 634

Cristina Januario

Instituto Superior de Engenharia de Lisboa - ISEL, Portugal

Co-Author(s): Blai Vidiella, Jorge Duarte, Nuno Martins, Pedro Puig, Josep Sardanyes

Abstract:

Habitat loss threatens biodiversity, yet its interaction with behavioural traits remains poorly understood. Using a resource-consumer-predator model in which predators can hunt cooperatively, we show that habitat loss and cooperation interact synergistically to accelerate trophic downgrading. Greater cooperation in hunting increases predator sensitivity to habitat loss, leading to earlier extinction, reduced coexistence, including the vanishment of chaotic coexistence between the three trophic levels. A generalized linear model confirms the non-additive nature of this interaction. Our results highlight the vulnerability of cooperative predators and the need for conservation strategies that account for nonlinear interactions between abiotic stressors and complex biological traits such as cooperative behaviours.

FINANCIAL STOCHASTIC MODELS DIFFUSION: FROM RISK-NEUTRAL TO REAL-WORLD MEASURE

Schedule: July 8 17:10-17:30 Room 634

Ahmed Kebaier

Universite Evry Paris-Saclay, France

Co-Author(s): Mohamed Ben Alaya, Djibril Sarr

Abstract:

The current work contributes to the development of stochastic models for credit spreads, frameworks for transitioning between risk-neutral (RN) and real-world (RW) measures, AI-driven calibration techniques, and a methodology for data quality measurement. These advancements aim to improve the precision and practical use of financial models. The methodology, based on Girsanov's theorem, is designed to incorporate real-world dynamics, making it crucial for risk management. The framework is built to be applicable to a variety of models, including models with non-additive noise, such as the CIR++ model. We validate the framework's versatility through case studies involving forecasts and stress tests.

THE FIRST MATHEMATICAL MODEL FOR ELK-WOLF INTERACTION IN YELLOWSTONE NATIONAL PARK USING E-SINDY ALGORITHM

Schedule: July 9 9:00-9:20 Room 634

Nitu Kumari

IIT Mandi, India

Abstract:

The ecological dynamics between elk and wolves in northern Yellowstone have been a focal point of long-term research, particularly following the reintroduction of wolves to the region. Although numerous studies have explored this prey-predator interaction from ecological and behavioral perspectives, there remains a lack of comprehensive analysis using mathematical modeling approaches capable of uncovering underlying dynamical patterns and system-level insights. In this study, we investigate the prey-predator dynamics of the elk--wolf system in northern Yellowstone National Park, USA, using a data-driven modeling approach. We used yearly population data for elk and wolves from 1995 to 2022 (28 years) to construct a mathematical model using a sparse regression modeling framework. To the best of our knowledge, no previous work has applied this framework to capture elk--wolf interactions over this time period. Our modeling pipeline integrates Gaussian process regression for data smoothing, sparse identification of nonlinear dynamics for model discovery, and model selection techniques to identify the most suitable mathematical representation. The resulting model is analyzed for its non-linear dynamics with ecologically meaningful parameters.

Variational modeling and numerical simulation of evaporating thin droplets and the coffee-ring effect

Schedule: July 9 17:10-17:30 Room 634

Yakun LI

The Hong Kong University of Science and Technology, Peoples Rep of China

Abstract:

Evaporating sessile droplets exhibit complex, multiscale dynamics driven by the coupling of interfacial evaporation, contact line motion, internal fluid flow, and vapor diffusion, leading to phenomena such as the coffee-ring effect. We develop a thermodynamically consistent thin-film model using Onsager's variational principle combined with the lubrication approximation. The framework incorporates viscous momentum transport, contact line motion, evaporation, and vapor diffusion in a unified setting. A characteristic length scale is introduced by considering the competition between the liquid evaporation at the liquid-gas interface and the vapor diffusion in the gas space, yielding a dimensionless parameter that distinguishes diffusion-limited and transition-limited regimes. Numerical simulations reveal distinct evaporation patterns and flow structures across regimes. We further investigate the coffee-ring effect for drying particle-laden droplets across different dynamic regimes with pinned and depinned contact lines.

Bipartite Flocking in A Time-Delayed Cucker-Smale Model under Spanning Tree Networks

Schedule: July 7 9:00-9:20 Room 634

Yu-Hao Liang

Department of Applied Mathematics, National University of Kaohsiung, Taiwan

Abstract:

Collective dynamics in multi-agent systems are significantly affected by time delays and antagonistic interactions. In this talk, we study a class of delayed Cucker-Smale models incorporating cooperation-competition mechanisms that lead to bipartite flocking behavior. We establish sufficient conditions for unconditional bipartite flocking under a directed interaction topology containing a spanning tree with a single leader. Our analysis highlights the interplay between delay effects and network structure, showing that convergence toward two coherent clusters can still be guaranteed despite communication lags. The theoretical results are complemented by numerical simulations that illustrate the emergence of bipartite alignment and validate the analytical conditions.

Do Low Internal Carbon Prices Signal Climate Inaction? A Financed-Emissions Perspective

Schedule: July 7 14:30-14:50 Room 634

Haibo Liu

Purdue University, USA

Abstract:

Using a low internal carbon price (ICP) is often viewed as evidence of climate inaction. Yet firms in the financial service and insurance industries adopt some of the lowest ICPs across all sectors, far below the ranges recommended by leading international climate bodies. In this paper, we rationalize these low ICPs by focusing on their financed emissions, which account for the vast majority of the total emissions for financial institutions. We develop and analytically solve an extended mean-variance model with a constraint on portfolio emissions. Our model identifies an emission-efficient frontier (EEF) for environmentally conscious investors. We use the EEF to analyze the expected impact of an internal carbon policy. Using emissions data from London Stock Exchange Group, we empirically estimate the EEF. According to our model, to maximize the firm's carbon-adjusted Sharpe ratio, the ICP should not exceed \$4.7 per tonne. Meanwhile, the estimated expected policy impact is high, and hence even a low ICP can reduce the firm's financed emissions substantially with little compromise in investment performance. Our findings support the use of low ICPs for financed emissions and call into question the practices of benchmarking ICPs uniformly across emission scopes against the price ranges recommended by the climate bodies.

Top-down regulation and catastrophic transition in an intraguild predation model driven by IG-prey's anti-predator nature

Schedule: July 8 14:30-14:50 Room 634

Debabrata Mandal

Indian Institute of Technology Roorkee, India

Co-Author(s): Sourav Kumar Sasmal

Abstract:

Intraguild predation (IGP) combines predation and competition. The significance of IGP-models in many natural groups is becoming increasingly clear. In these IGP-systems, we sometimes witness a notable ecological phenomenon called top-down regulation, in which predatory activity at a higher trophic level influences the community structure of lower trophic levels. This talk focuses on how the anti-predator behavior of dangerous IG-prey regulates the top-down effect in an ecosystem. To accomplish this, we developed a three-layered IGP-model incorporating the Holling type-I and type-IV functional responses for interactions of shared-prey with their predators and between IG-prey and IG-predators, respectively, along with the anti-predator behavior of IG-prey through direct killing of primarily juvenile predators. This study provides adequate requirements for all equilibria to exist and be locally stable for the proposed IGP-model. Sufficient conditions for species persistence and extinction are discussed analytically. Depending on the initial population size, the IGP-model exhibits hysteresis cycle and undergoes a catastrophic shift to extinction of the IG-predators by altering the strength of the IG-prey's group defense. In a nutshell, our IGP-model fails to show top-down regulation in the presence of the dangerous IG-prey's anti-predator nature, but in its absence, it does.

Modeling of integrated Fabry-Perot resonators

Schedule: July 8 17:30-17:50 Room 634

Carlos Mas Arabi

Institut Universitari de Matemàtica Pura i Aplicada, Universitat Politècnica de València, 46022 (València), Spain, Spain

Co-Author(s): J. Alberto Conejero; Salim Benadouda Ivars; David Artigas; Carles Milian

Abstract:

We derive, starting from Maxwell's equations, a set of models that describe integrated Fabry-Pérot resonators. Our work focuses on structures in which the mirrors are implemented through periodic variations of the refractive index, as commonly found in photonic crystal and Bragg-type configurations. Such systems exhibit rich optical behavior due to the interplay between confinement and periodicity. Our methodology is based on two complementary approaches. On one hand, we employ a modal expansion of photonic waveguides, which provides an intuitive and computationally efficient framework to describe guided modes and their interactions. On the other hand, we use the plane wave expansion method, which is particularly well suited to capture the effects of periodic media and accurately describe band structure properties. The goal of our models is to incorporate the complex dynamics arising from the underlying periodic crystal, going beyond simplified descriptions of resonator behavior. By doing so, we aim to account for effects such as dispersion engineering, mode coupling, and bandgap-induced confinement. This comprehensive framework opens the door to the exploration of new and potentially rich physical phenomena in integrated photonic resonators, with possible applications in optical communications, sensing, and quantum photonics.

Delayed consensus in discrete time networks

Schedule: July 9 8:40-9:00 Room 634

Nazira Murat

Bilkent University, Turkey

Abstract:

We investigate consensus dynamics in networks of coupled discrete-time linear dynamical systems in which agents anticipate the future states of its neighbors using past information. This anticipation mechanism introduces a delay term and incorporates memory into the consensus protocol. We analyze how anticipation affects the stability and the speed of consensus. In particular, we derive necessary and sufficient conditions under which anticipation leads to faster convergence compared to the undelayed case. On the other hand, the delays introduced by anticipation can also break consensus altogether under certain other conditions. Our analysis relies on the spectral properties of the graph Laplacian and shows that the convergence rate depends on the smallest nonzero and the largest eigenvalues of the Laplacian.

A Modeling Approach to Habitability Probabilities using Survival-Filtered Stellar Demographics with Biogeochemical Implications.

Schedule: July 9 17:30-17:50 Room 634

Nour A. Nabhan

American University of Armenia, Armenia

Abstract:

We present a redshift--time framework to study the comoving density of planetary systems that could, potentially, harbor life at an observation epoch. We adopt a flat LambdaCDM cosmology and combine a cosmic star-formation rate density with an initial mass function to compute the density of surviving host stars via a lifetime-based survival indicator. We then model physical habitability as the product of planet-centric factors (e.g., habitable-zone residence and rocky composition) and an environmental survival term expressed using hazard rates (e.g., gamma-ray bursts and AGN activity). Finally, we add a module that couples generalized stoichiometric physiology to a chemostat-style biogeochemical ODE system for nutrient--biomass dynamics, yielding an additional filter for the fraction of physically habitable planets that could sustain an active aqueous biosphere capable of producing chemical signatures.

MHD Stokes Flow past an Array of Staggered Circular Cylinders Inside Topographically Patterned Microchannel using Non-Primitive Boundary Element Method

Schedule: July 7 9:20-9:40 Room 634

Chandra Shekhar Nishad

International Institute of Information Technology, Naya Raipur, India

Co-Author(s): Vishal Chhabra, K.G. Vijay, and Manoj Sahni

Abstract:

The motivation for investigating Stokes flow through an array of staggered circular cylinders in a topographically patterned microchannel arises from a wide range of applications, including microfluidic devices, especially for cooling purposes, enhancing mass transport, noise control during aircraft landing, heat transfer enhancement, and so forth. Two-dimensional viscous incompressible, pressure-driven, creeping flow at low Reynolds number around a series of staggered circular cylinders in a topographically patterned microchannel is investigated numerically by using the boundary element method (BEM) based on a non-primitive variables approach. The non-primitive variables approach refers to the combination of stream function and vorticity variables. The Stokes equation is used to govern the flow of viscous fluid through a topographically patterned microchannel. We restrict ourselves to rectangular stepped asymmetric geometries. Moreover, we have assumed that a number of cylinders of equal diameter are present at the staggered position in the path of flow. We studied streamline and vorticity contour plots, velocity profiles, pressure gradients, and the shear stresses with varied step height, step width, step frequency, and the radius of the cylinder, to get a complete comprehension of flow dynamics. Additionally, the proposed investigation holds several potential applications, such as drug capsule delivery systems, hemodynamics, bio-MEMS technology, and so forth.

Exploring the basins of attraction of dynamical systems with delay

Schedule: July 7 14:50-15:10 Room 634

Evert Provoost

KU Leuven, Belgium

Co-Author(s): Francesca Scarabel

Abstract:

When modelling biological systems one often faces transport phenomena of which the details are irrelevant to the model, e.g. viral kinematics inside a host, the prepubescent development of an individual, etc. Two abstractions are possible, either one introduces an intermediate compartment and models transport as typical flow-rates between these compartments, or one introduces time-delay. Although the former is more common, the latter can yield richer models. In particular, time-delay can introduce intricate periodic and chaotic behaviours even in the scalar case, as illustrated by the celebrated Mackey--Glass equations. These models admit more complicated behaviours because the dependence on past values makes them inherently infinite-dimensional. The numerical study of a system's attractors and their basins is well-established for finite dimensional systems. In this work, we use ideas from approximation theory to develop analogous techniques for time-delayed models. Whilst similar to the techniques used in the delay-free case, the treatment of infinite-dimensionality yields novel challenges. In particular, we now have to find an interpretable projection to visualize the found basins. Throughout the presentation, we will illustrate these techniques using an SIR model with the inclusion of waning and boosting of immunity.

Modeling the impact of host diversity on the evolution of vector feeding preferences and implications for disease control

Schedule: July 8 14:50-15:10 Room 634

Shravani V Shetgaonkar

Birla Institute of Technology and Science, Pilani, K K Birla Goa Campus, India

Co-Author(s): Dr. Anupama Sharma

Abstract:

Vector-borne diseases often infect multiple host species, increasing the likelihood of disease persistence due to the presence of multiple reservoirs. Vector biting patterns and feeding preferences can shift in response to selective pressures introduced by disease control interventions, altering the dynamics of transmission. In this talk, we develop a mathematical model that couples host diversity and adaptive vector behavior with vector-borne disease transmission dynamics, focusing on a system with two distinct hosts and a vector population exhibiting preference for one host. We derive the basic reproduction number, R_0 , a threshold which determines the existence of two equilibria in our model, and obtain conditions that can lead to the long-term persistence of the disease. The analysis suggests that shortening the infectious period of the vector's preferred host is an effective control strategy. We also identify a threshold that determines whether shifting vector preference toward a non-preferred host amplifies or reduces the disease burden on the primary preferred host. We show that protective measures for the preferred host can trigger adaptive shifts in vector preferences, reducing disease prevalence in that host. However, this shift may lead to an increase in overall host prevalence.

The role of dormancy in population dynamics in fluctuating and uncertain environments

Schedule: July 9 17:50-18:10 Room 634

Ruben Taieb

INRIA, France

Co-Author(s): Mostafa Adimy, Pablo Amster

Abstract:

Many different biological organisms use dormancy to survive adverse conditions by entering a reversible state of reduced metabolic activity. We explore how it may allow for survival of a species when facing periodic stress, or catastrophic events. We study dormancy under periodic stress using a delayed chemostat-like model. Although dormancy yields no fitness advantage in constant environments, it becomes crucial for survival under seasonal fluctuations. We establish conditions for persistence using monotone systems and Floquet theory with delay, and determine an optimal dormancy strategy for survival of a species. Using a bistable model with and without spatial dynamics and studying its separatrix, we demonstrate that a bet-hedging dormancy strategy creates a fundamental ecological trade-off between resilience and invasiveness. While quiescence enhances resistance against catastrophic events and gradual environmental degradation, it simultaneously amplifies the Allee effect, effectively increasing environmental inertia. Ultimately, our studies reveal that while dormancy may often reduce the net growth rate and hinder expansion, appropriately tuned dormancy is a crucial mechanism for long-term survival in fluctuating and catastrophic or random environments.

Onsager Variational Principle - Guided Physics Informed Neural Networks for Simulating Interface Evolution in Cahn-Hilliard Equation

Schedule: July 7 15:10-15:30 Room 634

WENLIN ZHANG

Hong Kong University of Science and Technology, Peoples Rep of China

Abstract:

Based on the Onsager variational principle, we reformulate the Cahn-Hilliard equation as a gradient flow of free energy dissipation and establish the variational triple concentration c , chemical potential μ , and flux $\mathbf{J}$. A physics-informed neural network jointly outputs these three fields. An energy convex splitting architecture decomposes the free energy into convex and concave components, correspondingly splitting μ and $\mathbf{J}$ under independent supervision. This decouples interfacial relaxation from phase separation driving forces and inherently suppresses numerical stiffness. Numerical experiments show that the proposed method successfully captures the full coalescence of twin elliptic droplets: rounding, approach, merging, and coarsening, whereas the standard PINN remains trapped in a metastable separated state. This work provides a systematic variational framework for deep learning simulation of phase-field equations.

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