13th Americas Conference on Differential Equations and Nonlinear Analysis & ICMC Summer Meeting on Differential Equations

2023 CHAPTER

São Carlos - SP, Brazil
January 30 - February 3, 2023

In Memory of

James Muldowney & Geneviève Raugel

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- **Tomás Caraballo** - Universidad de Sevilla, Spain
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» Plenary Lectures
» Thematic Sessions
» Mini-courses
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Welcome

It is a pleasure to welcome you to the *13th Americas Conference on Differential Equations and Nonlinear Analysis* and the *ICMC Summer Meeting on Differential Equations - 2023 Chapter* and to São Carlos. We wish you a pleasant stay and that you enjoy the meetings.

Executive committee

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Local organizing committee

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Session Organizers

Marcio Gameiro (USP/Brazil) & Konstantin Mischaikow (Rutgers University/USA): Computational Dynamics.

Jean Silva (UFMG/Brazil) & Wladimir Neves (UFRJ/Brazil): Conservation Laws and Transport Equations.

Marcia A. G. Scialom (UNICAMP/Brazil) & Mahendra Panthee (UNICAMP/Brazil): Dispersive Equations.

José M. Arrieta (UCM/Spain) & Marcone C. Pereira (USP/Brazil): Domain Perturbations, PDEs and Dynamics.

Maria José Pacífico (UFRJ/Brazil), Ali Tahzibi (USP/Brazil) & Daniel Smania (USP/Brazil): Dynamical systems and Ergodic Theory.

Ederson Moreira dos Santos (USP/Brazil) & Marcos T. O. Pimenta (UNESP/Brazil): Elliptic Equations.

Anne Bronzi (UNICAMP/Brazil) & Gabriela Planas (UNICAMP/Brazil): Fluid Dynamics.

João Vitor da Silva (UNICAMP/Brazil), Disson dos Prazeres (UFS/Brazil) & Mariana Smit Vega Garcia (WWU/USA): Free Boundaries Problems and Related Topics.

Lucas Oliveira (UFGRS/Brazil) & Tiago Picon (USP/Brazil): Harmonic Analysis and Related Topics.

Pierluigi Benevieri (USP/Brazil), Everaldo de Mello Bonotto (USP/Brazil) & Jaqueline G. Mesquita (UnB/Brazil): Integral and Functional Differential Equations.

Igor A. Ferra (UFABC/Brazil) & Bruno de Lessa Victor (USP/Brazil): Linear Equations.

Yao Li (UMass Amherst/USA) & Zhongwei Shen (UAlberta/Canada): Multiscale Dynamics.

Raúl Manásevich (Uchile/Chile) & Gabrielle Nornberg (Uchile/Chile): Nonlinear Boundary Value Problems.

Phillipo Lappicy (UFRJ/Brazil) & Juliana Fernandes da Silva Pimentel (UFRJ/Brazil): Nonlinear Dynamical Systems.

Address

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Maps

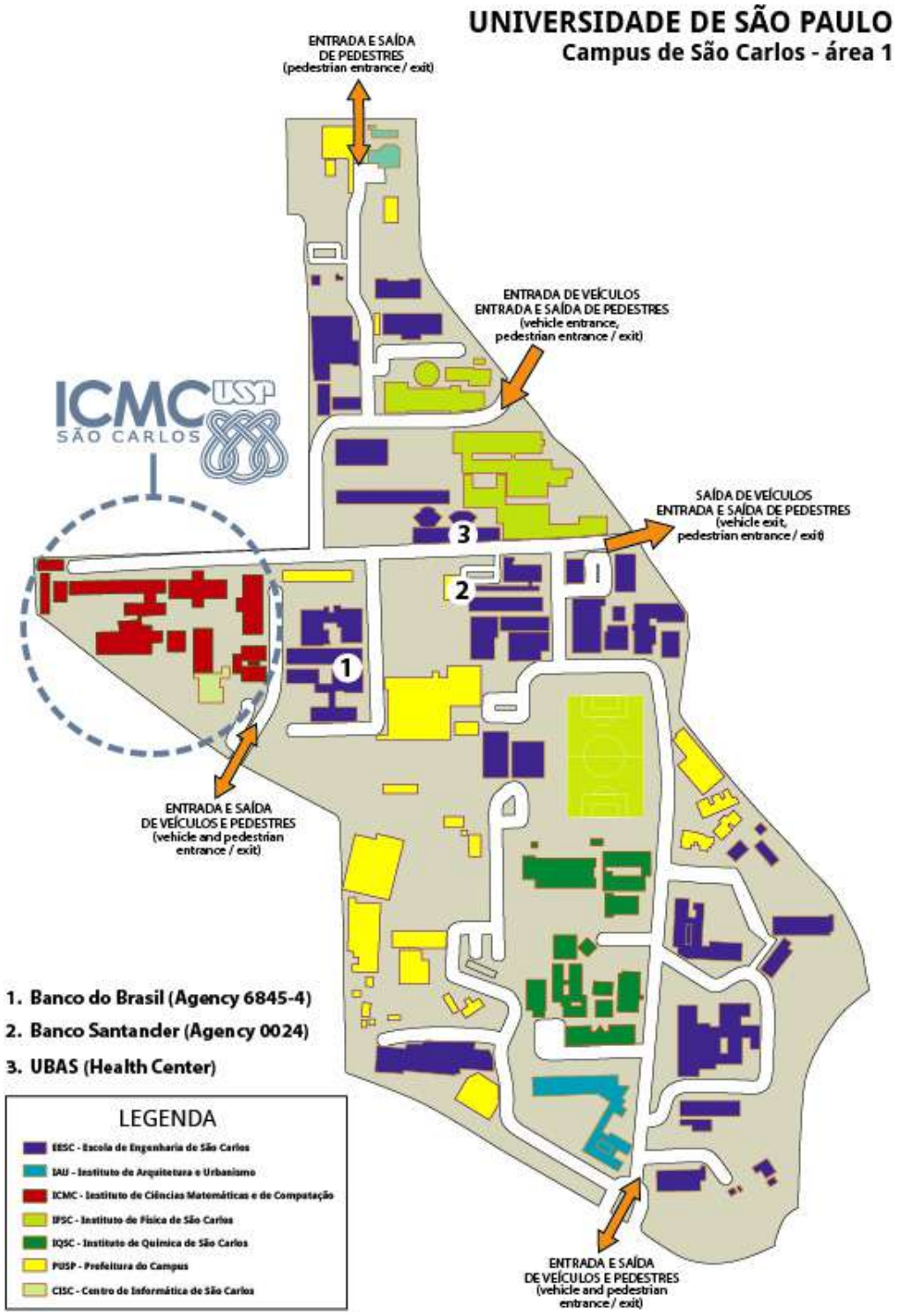

Figure 1: Campus map

Figure 2: ICMC map

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General Information

Conference site

The meeting will take place at Buildings 5 and 6. These buildings are indicated in the map on page 7.

Plenary talks and Session on Nonlinear Dynamical Systems will take place at the Auditorium (Building 6).

All other sessions will take place in Building 5.

Poster session will take place at Auditorium entrance.

The Coffee Room is on the ground floor of the Library (1, map on page 7).

Registration

The registrations will be made in the following schedule:

Sunday, January 29^{th}: From 16:00 to 18:00 in the entrance of the ICMC Auditorium (Building 6).

Monday, February 30^{th}: From 8:00 to 8:50 in the entrance of the ICMC Auditorium (Building 6).

Those who cannot register on Sunday or Monday can also do it during the week at any time.

We will provide you with a badge at registration. Please wear your badge at the event to access the event rooms.

The Events Office will set up a help desk at the entrance of the Auditorium and will be at your disposal for any questions and information, also the Events Office (3, map on page 7) will be at your disposal.

Registration Fees

Student Fee: R$ 100,00 (reais).

Regular Fee: R$ 200,00 (reais).

Financial support

The financial support from the local organizing committee will be available on Tuesday, January 31 and Wednesday, February 1^{st} from 13:00 to 15:00, at the help desk at the entrance of the Auditorium (Building 6, map on page 7). In order to receive your support, it is mandatory to completely fill out the on-line registration form available at `summer.icmc.usp.br/user_summer/` .

Meals and refreshments

There are several restaurants near the campus. A selection of restaurants, coffee shops, and hotels next to ICMC (walk distance) can be found at `https://icmc.usp.br/e/e0f70`.

Social events

Wednesday, February 1^{st}: Photo of the meeting at 10:40 at ICMC.

Wedneshay, February 1^{st}: Conference Banquet at 20:00 at ADUFSCar Restaurant - Cozinha do Lobo at Washington Luís Highway, 235 km.

Health emergencies

In case of accidents or health emergencies call 192 (SAMU).

Money exchanges

In case you need to exchange your money, we recommend:

• Confidence Câmbio at Shopping Center Iguatemi. The working hours are from 10:00 to 20:00 (Mon-Fri) and from 10:00 to 18:00 (Sat).

• JIS Câmbio at 1931, São Sebastião Street. The working hours are from 9:30 to 17:30 (Mon-Fri).

Smoking

Smoking is prohibited inside any of the ICMC buildings also in the canteen and on the ground floor of the library.

Computer and wireless LAN use

The University provides access to wireless internet connection via **eduroam**. If you do not possess an eduroam account you can access another of our wireless connection through the following steps:

1. Enable wireless on your device.
2. Join the ICMC-GUEST wireless network.
3. Open a browser and try to visit any website.
4. You will be redirected to a login page. Enter the login and password as follows:

   User Name: summer23

   Password: 23summer
5. You may freely browse the internet after logging in. You may occasionally need to re-authenticate using the above procedure.

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Minicourses

Minicourses

Applied Bifurcation Theory

Sue Ann Campbell
University of Waterloo

We review some basic concepts needed to explore bifurcations in ordinary differential equations: topological equivalence, codimension, and normal forms. We study the generic codimension-one bifurcations of equilibria and show how violation of nondegeneracy conditions gives rise to codimension-two bifurcations. Using models from mathematical biology, we show how the variation of one parameter can lead to a complex picture involving multiple bifurcations. We illustrate these ideas using numerical bifurcation software. If time permits, we will give a brief overview of some ideas underlying numerical bifurcation analysis, used in such software tools as AUTO and Matcont.

Computing the Global Dynamics of Parameterized Systems of ODEs

Konstantin Mischaikow and Marcio Gameiro
Rutgers University

We introduce an algorithmic approach to identifying the global dynamics of multiparameter systems of ordinary differential equations. Topics to be covered include the following.

1. *Combinatorial/Homological Dynamics.* We introduce a combinatorial framework for dynamics that allows for efficient identification of recurrent and non-recurrent dynamics. The recurrent and non-recurrent dynamics is expressed via a large lattice of forward invariant sets. We indicate how the essential information about the dynamics encoded in a chain complex called the Conley complex.

2. *Conley Theory.* We review Conley theory in the context of continuous dynamics generated by flows with a special emphasis on the lattice of attracting blocks, the Conley index, and how the index information can be used to identify the structure of invariant sets.

3. *Rook Fields.* We introduce rook fields, purely combinatorial finite analogues of continuous vector fields, and discuss a hierarchy of combinatorial dynamics that can be derived from rook fields. We remark that the combinatorial dynamics can be analyzed using the tools from (1).

4. *Ramp Systems.* We introduce a class of parameterized systems of ordinary differential equations called ramp systems and discuss how a rook fields can be used to represent ramp systems.

5. *Decomposition of Parameter Space.* In general ramp systems have high dimensional parameter spaces. We discuss how given a ramp system the associated parameter space can be decomposed into a finite number of explicit semi-algebraic sets with the property that for each semi-algebraic set the combinatorial dynamics of the associated rook field is constant.

6. *Computations.* We provide examples demonstrating how given a ramp system the associated Conley complex can be computed.

7. *Proving Transversality.* A ramp system gives rise to a rook field that gives rise to a lattice of forward invariant sets that gives rise to a Conley complex. We prove that the combinatorial structures upon which the rook field is defined can be geometrically realized as a CW complex within which the lattice of forward invariant sets defines a lattice of attracting blocks for the flow associated with the ramp system. This implies that the purely combinatorial computations of (1) are valid for the flow and thus Conley index information can be used to describe the invariant sets for the ramp system.

8. *Open Problems and Future Directions.* We explain why the computational results apply to larger classes of differential equations than just ramp systems, but the emphasis will be on the open question of whether this approach can be applied to an arbitrary system of ordinary differential equations. We discuss the hierarchy of combinatorial dynamics that can be derived from rook fields. For some forms of combinatorial dynamics we can prove transversality in arbitrary dimensions. For other forms of combinatorial dynamics we highlight the challenges of higher dimensional systems.

Predicting Epidemics using Differential Equation Models: Methods and Challenges

Michael Li
University of Alberta

Predicting Epidemics using Differential Equation Models: Methods, Challenges, and Case Studies

Throughout the COVID-19 pandemic, mathematical models based on differential equations have been widely and extensively used as research and policy tools by public health agencies around the world. Models are used to make predictions on the potential scale, duration, peak time and peak cases of infected individuals, as well as number of people in the hospitals and ICU with COVID-19. These predictions help public health agencies with planning and provide evidence for public health decision-making. While the overall impact of modelling on public health pandemic responses has been overwhelmingly positive, many challenges remained. Modellers were often frustrated when models fail to predict the peak time of a COVID-19 wave in advance.

In this series of four lectures, I hope to explain how differential equations are used to make predictions for epidemics, how to use public health data to train differential equations models, as well as many challenges we encounter in the process, and how these challenges can be dealt with to make reliable and accurate long-term predictions of epidemics such as COVID-19 and seasonal influenza.

Lecture 1: Basic mathematical theory of epidemics, simple model fitting to data. The iceberg challenge.

In this lecture, the standard SIR models using differential equations are explained, together with relevant epidemiological terms. The least-squares method is used to find the best parameter values by fitting number of infected $I(t)$ to the corresponding data. Then we examine the real public health data that are available for modelling fitting: the number of positive tests per day. Using iceberg to illustrate an epidemic, the number of positive tests $C(t)$ is the tip of iceberg that we can directly observe, while the number of infected $I(t)$ is the entire iceberg. Let k be the ratio between the tip and the entire iceberg, model fitting is to minimize the error $||kI(t) - C(t)||$. Due to the presence of asymptomatically infected people, the ratio k is also unknown. We have a situation that data $C(t)$ can only determine the product $kI(t)$ of two unknowns. There are infinitely possible parameter choices can produce best model fit to the tip of iceberg, while different best-fit parameter values can lead to significantly different model predictions of the entire iceberg, rendering model prediction

unreliable. This is the iceberg challenge to the model prediction of epidemics. Mathematically, the nonuniqueness of best-fit parameter values is called nonidentifiability. This is our first major challenge.

Lecture 2: Bayesian inference for dynamical system models and model selection.

In this lecture, we will briefly introduce Bayesian inference and how to apply that to differential equation models for model fitting to data, and the associated concept of likelihood functions and Markov chain Monte Carlo (MCMC) algorithms. Compare to other methods for model fitting to data (or model calibration/model training) including the maximum likelihood method, the Bayesian inference approach is particularly suited for differential equation models in the sense that the calibrated ODE models becomes stochastic model, and model predictions are stochastic processes. Another important topic in model predictions is model selection. This deals with the trade-off between more realistic models and limitation of available data. Realistic models are more complex than simpler models with more parameters that need to be estimated from model fitting to data. When the available data is given, the more parameters to be fitted the more serious the nonidentifiability problem, and more uncertainty in model predictions, and predictability suffers. This trade off between model complexity and model predictability is best described by the famous quote "Models should be as simple as possible, but not simpler". How to determine the most suitable model to use for a given data set? This is determined by the model selection process using information criteria such as Akaike information criteria (AIC). The idea of model selection often runs counter intuitive to the standard teaching of modelling, where the belief is models that incorporate best available science will make the best predictions. To overcome this belief is our second major challenge.

Lecture 3: Influenza predictions using differential equations, a case study.

In this lecture, I will use Influenza prediction as an example to demonstrate the challenges we encounter, and how to overcome them to make reliable and accurate long-term predictions of the time course of seasonal influenza.

Lecture 4: Why do differential equation models over-project COVID-19 epidemics?

In this lecture, I will explain the mathematical reason why our models, simple or complex, always tend to over-project local epidemics of COVID-19. We will revisit the final-size formula and see how it dictates the final size of an epidemic (and it is always unrealistically high). The final size challenge is our most serious challenge.

I will leave some questions for the audience regarding our understanding (or lack of) of real-world epidemics, and our understanding (or lack of) of our own models. This relates to what has become an emerging hot topic in epidemic modelling: incorporating human behaviours into epidemic models.

PDE Techniques Applied to Game Theory

Nicolas Saintier
Buenos Aires

In these lectures, I will present some tools from game theory and kinetic equations to model large population of agents interacting rationnally through games.

Random Dynamical Systems

Jeroen Lamb
Imperial College London

This short course will provide an introduction into random dynamical systems. The following topics will be covered: (1) Iterated Function Systems with probabilities as random dynamical systems. (2) Pitchfork bifurcation with additive noise: a case study in the random dynamics of 1D SDEs. (3)

The dynamics of random circle homeomorphisms. (4) Minimal invariant sets of random dynamical systems with bounded noise, and their bifurcations.

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Plenary Lectures

Plenary Lectures

An introduction to threshold-linear networks for neuroscience

Carina Curto
Penn State University

Threshold-linear networks (TLNs) are popular models for modeling neural activity in the brain. They are simple, recurrently-connected networks with a rich repertoire of nonlinear dynamics, including multistability, limit cycles, quasiperiodic attractors, and chaos. Over the past few years, we have developed a mathematical theory relating stable and unstable fixed points of TLNs to graph-theoretic properties of the underlying network. The resulting "graph rules" provide a direct connection between network architecture and key features of the dynamics. In this talk, I will provide an introduction to the theory of TLNs via a mix of theorems and examples. In a selection of applications, I will show how the theory enables us to design networks that perform various neural computations, such as counting stimulus pulses, position tracking, and transitioning between various locomotive gaits.

Pontryagin's Maximum Principle for optimal control problems governed by nonlinear impulsive differential equations

Hugo Leiva
Yachay Tech

In this paper, we derive the Pontryagin's Maximum Principle for optimal control problems governed by non linear impulsive differential equations. Our method is based on Dubovitskii-Milyutin Theory, but in doing so, we assumed that the linear variational impulsive differential equation around the optimal solution is exactly controllable, which can be satisfied in many cases. Then, we consider an example as an application of the main result. After that, we study the case when the differential equation is of neutral type. Finally, several possible problems are proposed for future research where the differential equation, the constraints, the time scale, the impulses, etc. are changed.

Phase Separation in Heterogeneous Media

Irene Fonseca
Carnegie Mellon University

Modern technologies and biological systems, such as temperature-responsive polymers and lipid rafts, take advantage of engineered inclusions, or natural heterogeneities of the medium, to obtain novel composite materials with specific physical properties. To model such situations by using a variational approach based on the gradient theory, the potential and the wells may to depend on the spatial position, even in a discontinuous way, and different regimes should be considered.

In the critical case case where the scale of the small heterogeneities is of the same order of the scale governing the phase transition and the wells are fixed, the interaction between homogenization and the phase transitions process leads to an anisotropic interfacial energy.

In the subcritical case with moving wells where the heterogeneities of the material are of a larger scale than that of the diffuse interface between different phases, it is observed that there is no macroscopic phase separation and that thermal fluctuations play a role in the formation of nanodomains. The supercritical case for fixed wells is also addressed, and a partial characterization of the limit energy is given. This is joint work with Riccardo Cristoferi (Radboud University, The

Netherlands) and Likhit Ganedi (Aachen University, Germany), based on previous results also obtained with Adrian Hagerty (USA) and Cristina Popovici (USA).

Fully nonlinear degenerate elliptic operators: strong maximum principle and other stories

Isabeau Birindelli
Università di Roma "La Sapienza"

For a class of degenerate fully nonlinear operators so called truncated Laplacian, I will present results related to the strong maximum principle or better the lack of it; I will give a geometrical characterization of the zero level set for non-negative supersolutions for operators that don't satisfy the strong maximum principle. The point of view is quite different from the classical "sharp maximum principle" of Bony. (joint work with Galise and Ishii). I will also present a joint work with Galise and Topp, where we introduce some nonlinear extremal nonlocal operators that approximate the truncated Laplacians. For these operators we construct representation formulas that lead to the construction of what, with an abuse of notation, could be called "fundamental solutions". This, in turn, leads to Liouville type results. The interest is double: on one hand we wish to "understand" what is the right way to define the nonlocal version of the truncated Laplacians, on the other, we introduce nonlocal operators whose nonlocality is on one dimensional lines, and this dramatically changes the prospective, as is quite clear from the results obtained that often differs significantly with the local case or with the case where the nonlocality is diffused.

Results for FDEs with state-dependent delays

Jaqueline Godoy Mesquita
Universidade de Brasília

In this talk, I will present results concerning the existence and uniqueness of solutions for functional differential equations with state-dependent delays and present some applications. Also, I will discuss the neutral FDEs with state-dependent delays, presenting a linearized instability principle for these equations. This talk is based on the works [1] and [2].

References:

[1] H. Henríquez, J. G. Mesquita, H. C. dos Reis, Existence results for abstract functional differential equations with infinite state-dependent delay and applications, Mathematische Annalen, 2023, to appear.

[2] B. Lani-Wayda, J. G. Mesquita, Linearized Instability Principle for neutral FDEs with state-dependent delays, in preparation.

Localized radial and non-radial solutions of elliptic equations on unbounded domains: computer-assisted proofs of existence

Jean-Philippe Lessard
McGill University

Ground state solutions of elliptic problems have been analyzed extensively in the theory of PDEs, as they represent fundamental spatial patterns in many model equations. While the results for scalar equations, as well as certain specific classes of elliptic systems, are comprehensive, much less is known about these localized solutions in generic system of nonlinear elliptic equations. In the first part of

this talk we present a general method to prove constructively the existence of radially symmetric solutions of elliptic systems on infinite domains. These solutions are essentially described by systems of non-autonomous ordinary differential equations, which we study using dynamical systems theory and computer-assisted proof techniques, combining a suitably chosen Lyapunov-Perron operator with a Newton-Kantorovich type theorem. In the second part of this talk, we introduce a purely spectral method which uses approximation of eigenfunctions by periodic functions on large enough cubes to prove existence of non-radial solutions on infinite domains. This requires bounding norms of the inverse of the linearization of differential operators on unbounded domains and a finite-dimensional trace theorem from which we build smooth functions with support on a hypercube. We demonstrate the power of these methodologies by proving specific localized solutions of the 3D cubic Klein-Gordon equation, the 2D Swift-Hohenberg equation, and a three-component 2D FitzHugh-Nagumo system. The results on radial solutions is joint work with J.B. van den Berg (VU Amsterdam) and O. Hénot (McGill), while the purely spectral approach for non-radial solutions is joint work with M. Cadiot (McGill) and J.-C. Nave (McGill).

The Uniform Shape of Slowly Oscillating Solutions of Delay-Differential Equations

John Mallet-Paret
Brown University

We study singularly perturbed delay-differential equations of Mackey-Glass type,

$$\varepsilon \dot{x}(t) = -x(t) + f(x(t-r)),$$

in which (among other conditions) negative feedback and instability of the origin are assumed, namely $xf(x) < 0$ for $x \neq 0$, and $f'(0) < -1$. For a constant delay $r > 0$ we show that slowly oscillating solutions (which are not necessarily periodic) assume a uniform square-wave shape for small ε. This result was established for such solutions with period $2 + O(\varepsilon)$ over thirty years ago; here we extend it to general slowly oscillating solutions. This entails, in particular, obtaining uniform estimates on the shape of such solutions which are independent of the period. We also mention some related and open issues for the case of state-dependent delay $r = r(x(t))$.

Boundedness of solutions of nonautonomous logistic equations

José M. Arrieta
Universidad Complutense de Madrid

We consider a reaction diffusion equation in a bounded domain with logistic reaction term of the type $\lambda u - n(t,x)u^\rho$ and nonnegative initial data where the function $n(t,x)$ vanishes in a time dependent subset $K(t)$. We are interested in understanding how the behavior of the set $K(t)$ affects the asymptotic behavior of the solutions. Actually, we would like to decide when solutions are bounded as times goes to infinity and characterize when solutions become unbounded as times goes to infinity.

Partial differential equations in rough thin domains

Marcone C. Pereira
Universidade de São Paulo

In this lecture we will discuss some results which are associated with the asymptotic behavior of the solutions of boundary value problems posed in thin bounded domains with highly rough boundary. We

intend to present pioneering and recent results, highlighting the motivation for this type of research proposal, the mathematical methods used and the advances obtained over the years. In this context, we will see that it is necessary to combine several mathematical analysis techniques involving areas such as Functional Analysis, Homogenization Theory, Asymptotic Analysis and Domain Perturbation.

Old and new on Lorentz attractors

Maria José Pacífico
Universidade Federal do Rio de Janeiro

Ever since its discovery in 1963 by Lorenz [1], the Lorenz attractor has been playing a central role in the research of singular flows, i.e., flows generated by smooth vector fields with singularities. In this talk we shall survey about old and new results describing the dynamics of this kind of attractors from the topological as well as the ergodic point of view.

References:

[1] Lorenz, E. N., Deterministic nonperiodic flow, Journal of the atmospheric sciences, volume 20, pages 130-141, 1963.

Seminodal solutions to a system of nonlinear Schrödinger equations

Mónica Clapp, Felipe Angeles, Alberto Saldaña, Mayra Soares
Universidad Nacional Autónoma de México

We consider a system of nonlinear Schrödinger equations that emerges as a model in physical phenomena, for example, in the study of standing waves for a mixture of Bose-Einstein condensates of several hyperfine states that overlap in space.

We will show the existence of solutions whose components have prescribed signs, some of them are positive and others are nonradial and change sign. We will also give an upper bound for the lowest possible energy of this type of solutions. This bound is based on the fact that the components decay exponentially at an optimal rate.

We will present a result that describes the precise asymptotic decay of the components of the solutions to general nonlinear Schrödinger systems.

Some of these results are joint work with Mayra Soares (Universidade Federal de Goiás), and others with Felipe Angeles and Alberto Saldaña (Universidad Nacional Autónoma de México).

On the monotonicity of the period for some (non-local) equations with a p-Laplace operator

Raul Manasevich
Universidad de Chile

We deal with monotonicity properties of the *minimal period* of positive periodic solutions of

$$\big(\phi_p(w')\big)' + V'(w) = 0, \tag{1}$$

where $p \geq 2$, $\phi_p(s) = |s|^{p-2}s$, and $V : \mathbb{R} \to \mathbb{R}$ is smooth.

The potential function $V(w)$ is assumed to be non-negative for $w \geq 0$, $V(0) > 0$, it has a minimum at $w = A > 0$ with $V(A) = 0 = V'(A)$, and is such that the equation has positive periodic solutions enclosing the critical point $(A, 0)$ in the phase plane (w, w').

We review first some classical results of Chow and Wang and Chicone for $p = 2$ and show how to extend them to the case $p > 2$. We then consider the monotonicity of the period for equation (1), for a certain V function. This problem is connected with the minimization problem:

$$\mu(\lambda) := \inf_{f \in W^{1,p}(\mathbb{S}^1 \setminus \{0\}} \frac{\|f'\|^2_{L^p(\mathbb{S}^1)} + \lambda \|f\|^2_{L^p(\mathbb{S}^1)}}{\|f\|^2_{L^q(\mathbb{S}^1)}} \tag{2}$$

where $q > p$ is an arbitrary exponent and $\mathbb{S}^1$ is the unit circle. The corresponding Euler-Lagrange equation is a non-local nonlinear differential equation that can be transformed to an equation like (1).

Selection Methods for Hamilton Jacobi Solutions

Renato Iturriaga
Centro de Investigación en Matemáticas

It is well understood the moduli of solutions of the Hamilton Jacobi equation. It is also understood that certain one parameter perturbations of the equation give uniqueness. Most important, elliptical perturbations and discount equations. As the parameter vanishes it raises the question if the limit exists and therefore selects a solution. We will discuss the answers to this question.

Dynamics of stochastic PDEs: a survey

Tomás Caraballo
Universidad de Sevilla

The aim of this talk is to provide a survey on different aspects related to the dynamics of systems modeled by stochastic partial differential equations. We first report on the dynamics of random dynamical systems generated by stochastic PDE with linear multiplicative or additive noise. The main technique is a conjugation transformation which allows us to obtain a random dynamical system generated by the original stochastic problem. However, when the noise is more general than additive or multiplicative, this transformation does not work, but we still have two other alternatives to handle our problem. The first one consists in approximating the noisy term by a Wong-Zakai approximation (also called colored noise). In this way we can consider a random partial differential equation which generates a random dynamical system and the theory of random dynamical systems can be applied. A reason justifying this approach is that the random dynamical system generated by the Wong-Zakai approximation converges to the random dynamical system generated by the stochastic problem when the noise is additive or multiplicative. However, the convergence for general multiplicative noise is still unsolved. The second approach to analyze the case of nonlinear multiplicative noise is to apply the theory of weak mean random attractor which provides interesting information about the dynamics of the problem in an appropriate phase space. Additional results on the existence of invariant measures will complete our talk.

Response solutions in forced nonlinear oscillators

Yingfei Yi, Wen Si, Lu Xu
University of Alberta & Jilin University

For a forced nonlinear oscillator with time-dependent forcing, response solutions are the ones preserving the harmonic properties of the forcing. For instance, if the oscillator is quasi-periodically (periodically) forced, then response solutions are quasi-periodic (periodic) ones whose frequencies

(frequency) coincide(s) with that of the forcing function. The study of these solutions has been an important classical top in understanding the stability, harmonic property, and synchronizing behaviors of forced nonlinear oscillators. Its development actually motivates several areas of modern dynamics like the persistence theory of normal hyperbolicity and KAM theory.

This talk will present an overview of the topic as well as some recent progress in studying response solutions in quasi-periodically forced oscillators with degeneracy and/or singular perturbations. The case of stochastic forcing will also be discussed.

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Thematic Sessions

Conservation Laws and Transport Equations

Organizer: Jean Silva (UFMG/Brazil) & Wladimir Neves (UFRJ/Brazil)

A modular Caffarelli-Kohn-Nirenberg inequality

Aldo Bazán, Wladimir Neves
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A Caffarelli-Kohn-Nirenberg (CKN) type inequality is a functional interpolation inequality involving the gradient on the right side of the inequality. Different versions of this inequality are known in the literature, considering higher order derivatives, definite integrals in limited domains, and others. In this lecture we consider the test functions define in the euclidean space Rn, and present an analysis of the relationship between the exponents, and their effects on the CKN when these are constants, and when they are variables.

Riemann solutions for a 3x3 system of conservation laws modeling polymer flooding in porous media

Aparecido Souza, Dan Marchesin
Universidade Federal da Paraiba

In this work we consider the Riemann problem for the folowing system of three conservation laws for a three-phase flow in a porous media taking into account the injection of a small quantity of polymer in the water phase to increase its viscosity and to improve the oil production, [1, 2],

$$\begin{cases} \begin{cases} (s_w)_t + f_w(s_w, s_o, c)_x = 0 \\ (s_o)_t + f_o(s_w, s_o, c)_x = 0 \end{cases} & \text{(two phase-flow)}, \\ (cs_w)_t + (cf_w(s_w, s_o, c))_x = 0 & \text{(polymer flow)} \end{cases} \tag{3}$$

where s_w, s_o and $s_g = 1 - s_w - s_g$ are the water, the oil and the gas phase saturations, and c is the concentration of the polymer in the water phase. The flux functions in system (3) are $f_w = \frac{s_w^2}{\mu_w(c)\, D}$, $f_o = \frac{s_o^2}{\mu_o\, D}$, where $D = s_w^2/\mu_w(c) + s_o^2/\mu_o + (1 - s_w - s_o)^2/\mu_g$, and $\mu_w(c)$, μ_o, μ_g are the phase viscosities. The system (3) is non-strictly hyperbolic; two of its characteristic speeds, denoted by λ^s and λ^f, with $\lambda^s \leq \lambda^f$, are associated to the two-phase flow subsystem, while the third one, denoted by λ^c, is linearly degenerate and corresponds to contact discontinuities, [2]. There are two coincidence surfaces interior to the state space along which $\lambda^s = \lambda^c$ and $\lambda^f = \lambda^c$, respectively. The coincidence $\lambda^s = \lambda^f$ occurs along a curve parametrized by c consisting to *umbilic* points of the two-phase flow for each constant c. The are no triple coinciences $\lambda^c = \lambda^s = \lambda^f$ in the interior of the state space. We consider the viscous profile entropy criterion with the identity viscosity matrix for shock waves with constant c and the monotonicty of c for contact discontinuities. Under such entropy criteria we apply the wave curve method, [3, 4], and its computational implementation, to construct Riemann solutions for a class of initial data of practical interest.

References:

[1] E. Isaacson. Global solution of a Riemann problem for a nonstrictly hyperbolic system of conservation laws arising in enhanced oil recovery. *Rockefeller University preprint*, 1981.

[2] A. de Souza. Wave Structure for a Nonstrictly Hyperbolic System of Three Conservation Laws. *Mathl Comput Modeling*, 22, pp. 1–29, 1995.

[3] T. P. Liu. The Riemann problem for general systems of conservation laws. *J. Diff. Eqs.*, 18, pp. 218–234, 1975.

[4] A. Azevedo, A. de Souza, F. Furtado, D. Marchesin, B. Plohr. The Solution by the Wave Curve Method of Three-Phase Flow in Virgin Reservoirs. *Transp. Porous Media*, 83, 99–125, 2010.

Invariant measures for stochastic conservation laws with Lipchitz flux in the space of almost periodic functions.

Claudia Lorena Espitia, Hermano Frid, Daniel Marroquin
Instituto de Matemática Pura e Aplicada

We study the long-time behavior of almost periodic solutions to stochastic scalar conservation laws in any space dimension, under the assumption of Lipschitz continuity of the flux functions and a non-degeneracy condition. We show the existence and uniqueness of an invariant measure in the space of Besicovitch almost periodic functions.

Well-posedness and asymptotic behaviour of solutions to stochastic degenerate parabolic-hyperbolic equations

Daniel Marroquin, Hermano Frid, Claudia Lorena Espitia
Universidade Federal do Rio de Janeiro

We prove the well-posedness of solutions to stochastic degenerate parabolic hyperbolic equations. We generalize the existence and uniqueness results that are known for periodic solutions to almost periodic initial data. In particular, we construct an L^1-semigroup of solutions in the Bohr compact associated with $AP(R^N)$, for which an L^1-contraction property holds. We also study the long time behaviour of solutions in a subspace of $AP(R^N)$, by establishing an isometric correspondence of the L^1-semigroup of solutions with periodic solutions of an associated degenerate stochastic parabolic-hyperbolic equation, whose regularity properties we are able to exploit. This is a joint work with Hermano Frid and Claudia Espitia.

Dirichlet Problem for Degenerate Fractional Parabolic Hyperbolic Equations

Gerardo Huaroto, Wladimir Neves
Universidade Federal de Alagoas

We are concerned in this paper with the degenerate fractional diffusion advection equations posed in bounded domains. Due to a suitable formulation, we show the existence of weak entropy solutions for measurable and bounded initial and Dirichlet boundary data.

Moreover, we prove a L^1-type contraction property for weak entropy solutions obtained via parabolic perturbation. This is a weak selection principle which means that the weak entropy solutions are stable in this class.

Traveling wave solution profiles for the foam flow in porous media

Grigori Chapiro
Universidade Federal de Juiz de Fora

Foam is used in enhanced oil recovery to improve sweep efficiency by controlling gas mobility. A common way to describe the foam displacement is by using population balance models of partial differential equations, which consider the foam texture as part of the gas phase. Numerical simulation of such equations presents serious difficulties connected to the high non-linearity in the fractional flow.

In this talk, we address the solutions of the models describing the foam flow in porous media in the context of traveling waves. Mainly, we are interested in the case of one-dimensional incompressible two-phase gas-liquid flow in a porous medium in the presence of foam. All semi-analytical results were verified through direct numerical simulations, evidencing the applicability of the presented analysis.

Lagrangian Structure of Relativistic Vlasov Systems

Henrique Borrin de Souza, Diego Marcon Farias, Marcelo Martins Santos
Universidade Estadual de Campinas

In this talk, we study the Lagrangian structure of relativistic Vlasov systems as in [1], such as the relativistic Vlasov-Poisson and the relativistic quasi-electrostatic limit of Vlasov-Maxwell equations. We show that renormalized solutions of these systems are Lagrangian and that these notions of solution, in fact, coincide. As a consequence, finite-energy solutions are shown to be transported by a global flow. Moreover, we extend the notion of generalized solution for “effective" densities and we prove the existence of such solutions. Finally, under a higher integrability assumption of the initial condition, we show that solutions have every energy bounded, even in the gravitational case. These results extend to our setting those obtained by Ambrosio, Colombo, and Figalli [2] for the Vlasov-Poisson system; here, we analyze relativistic systems and also consider the contribution of the magnetic force into the evolution equation. Moreover, we discuss the main difficulties in order to extend these type of results for Vlasov-Maxwell systems, such as hyperbolicity of the electromagnetic field and evolution of initial conditions of these fields. Nevertheless, the main strategy of equivalence of renormalized and Lagrangian solutions still holds, as well as the definition of generalized solutions.

References:

[1] H. Borrin de Souza, D. Marcon. On the Lagrangian structure of transport equations: relativistic Vlasov systems. *Math. Methods in the Appl. Sciences*, to appear.

[2] L. Ambrosio, M. Colombo, and A. Figalli. On the Lagrangian structure of transport equations: the Vlasov-Poisson system. *Duke Math. J.*, 166(18):3505–3568, 2017.

Two-tube model of miscible displacement: travelling waves and normal hyperbolicity

Yulia Petrova, Sergey Tikhomirov, Yalchin Efendiev
Instituto de Matemática Pura e Aplicada

We study the motion of miscible liquids in porous media with the speed determined by Darcy's law. The two basic examples are the displacement of viscous liquids and the motion induced by gravity. Such motion often is unstable and creates patterns called viscous fingers (or gravitational fingers). We concentrate on important for applications property of viscous fingers - speed of their propagation. The work is inspired by the results of F. Otto and G. Menon for a simplified model, called transverse flow equilibrium (TFE). In this work a rigorous upper bound was proved using the

comparison principle. At the same time numerical experiments suggest that the actual speeds are better than Otto-Menon estimates. We consider a two-tubes model - the simplest model we were able to construct which includes transverse liquid flow. For this model for the gravitational fingers we were able to find families of travelling waves and the relation between original model and TFE simplification. The main tool in the proof is normal hyperbolicity. For viscous liquid it seems that the phenomenon is the same but up to now it is work in progress.

Velocity Averaging Lemmas for General Second-Order Equations

João Fernando Nariyoshi
Universidade Estadual de Campinas

In this talk, we will present and discuss some old and new theorems regarding the regularity of the so-called velocity averages

$$\int_{\mathbb{R}_v} f(\mathbf{x}, v)\psi(v)\, dv.$$

Here, $\psi(v)$ is a given real function, and $f(\mathbf{x}, v)$ solves a general, multidimensional second-order equation of the form

$$\sum_{j=1}^{N} \mathbf{a}_j(v)\frac{\partial f}{\partial \mathbf{x}_j}(\mathbf{x}, v) - \sum_{j,k=1}^{N} \mathbf{b}_{jk}(v)\frac{\partial^2 f}{\partial \mathbf{x}_k \partial \mathbf{x}_k}(\mathbf{x}, v) = g(\mathbf{x}, v).$$

As P.-L. Lions, B. Perthame, and E. Tadmor [*J. Amer. Math. Soc.* **7** (1994) 169–191] brilliantly demonstrated, these results, commonly known as "velocity averaging lemmas," have profound consequences in the theory of degenerate hyperbolic-parabolic equations such as

$$\frac{\partial \varrho}{\partial t} + \sum_{j=1}^{N} \frac{\partial}{\partial x_j}\mathbf{A}_j(\varrho) - \sum_{j,k=1}^{N} \frac{\partial^2}{\partial x_j \partial x_k}\mathbf{B}_{jk}(\varrho) = 0.$$

We provide novel compactness and Sobolev regularity principles for such velocity averages, thus justifying and extending several propositions envisioned in the celebrated work of Lions–Perthame–Tadmor. Moreover, we also derive some criteria for technical hypotheses known as "non-degeneracy conditions"; in this fashion, we generalize and correct all the known examples of equations that satisfy such assumptions.

Global existence results for solutions of general conservative advection-diffusion equations in R

Juliana Sartori Ziebell, Patrícia Lisandra Guidolin, Linéia Schütz, Janaína Pires Zingano
Universidade Federal do Rio Grande do Sul

In this talk, a rigorous study concerning global existence results and estimates for the sup norm of non-negative bounded solutions for one-dimensional advection-diffusion equations $u_t+(b(x,t)u^{k+1})_x = \mu(t)u_{xx}$, with $0 \leq k < 2$ and initial data $u_0 \in L^1(\mathbb{R}) \cap L^\infty(\mathbb{R})$ is provided using a technique based on energy methods. In respect of the arbitrary advective speed term, it is only assumed that $b(x,t)$ and $\partial b(x,t)/\partial x$ are limited.

The aim is to investigate for which values of k it is possible to guarantee the global existence of solutions to the problem. For this purpose, knowing that solutions can be extended to broader intervals of existence as long as they remain limited, it is important to examine the behavior of high

norms in the $[0, T_*)$, in particular, the L^∞-norm. This is a joint work with Linéia Schütz, Patrícia L. Guidolin and Janaína P. Zíngano.

A numerical algorithm for computing doubly nonlocal fractional conservation laws

Julio C. Valencia-Guevara, Eduardo Abreu, Magdalena Huacasi-Machaca, John Pérez
Universidad Nacional de San Agustín de Arequipa

We are concerned with the study of 1D doubly nonlocal fractional conservation laws

$$\partial_t u \pm \partial_x (u \Lambda^{\alpha-1} \mathcal{H} u) = 0,$$

where $\Lambda^{\alpha-1}$ denotes the Riesz potential transform and $\mathcal{H}$ denotes the Hilbert transform. We undertake a numerical-analytical study for an I.V.P. associated with such models to show evidence of blowing-up, among other qualitative properties, on nonlinear doubly nonlocal interaction between Hilbert transform and Riesz potential. To this aim, we developed a feasible algorithm for numerical computing of $\Lambda^{\alpha-1}$. In addition, we have derived error estimates for finite difference approximations of the Riesz Potential operator. We also constructed an improved fully-discrete Lagrangian-Eulerian scheme based on the concept of no-flow curves to handle the *doubly nonlocal nonlinear operator* $\Lambda^{\alpha-1}\mathcal{H}$ acting on the conservation laws. Numerical experiments are carried out to show the effectiveness of the approach for computing doubly nonlocal fractional conservation laws.

Concentration-compactness type principle for fractional Systems and applications

Lauren Maria Mezzomo Bonaldo, Elard J. Hurtado, Wladimir Neves
Universidade Federal do Rio de Janeiro

In this talk, we obtain a concentration-compactness type principle for fractional Sobolev spaces with variable exponents. As an application of the result, we obtain the existence of solutions for a class of critical nonlocal systems with variable exponents.

Decay of Entropy Solutions of a Scalar Conservation Law Beyond a Stationary Ergodic Setting

Luís Fernando Salvino, Jean Carlos da Silva
Universidade Federal de Minas Gerais

In this work, we prove the asymptotic decay of the Cauchy problem for a muldimensional scalar conservation law with initial data being a Besicovitch ergodic functions or the composition of stationary functions with stochastic deformations.

Weak solution for Stochastic Degasperis-Procesi Equation

Nikolai V. Chemetov, Fernanda Cipriano
Universidade de São Paulo

We study the stochastic Degasperis-Procesi equation with a multiplicative noise, in the one-dimensional domain $\mathbb{R}$

$$\begin{cases} du = -\left(u\partial_x u + \partial_x \mathrm{p}\right)\ dt + \sigma(x,u) d\mathcal{W}_t, \\ \left(1 - \partial_{xx}^2\right)\mathrm{p} = \frac{3}{2}u^2 \quad \text{in } \mathbb{R}_T = (0,T)\times\mathbb{R}, \\ u(0) = u_0 \qquad\qquad\qquad\quad \text{in } \mathbb{R}, \end{cases} \tag{4}$$

where $u = u(t,x)$ denotes the velocity of the fluid, $u_0 = u_0(x)$ is the initial velocity, and σ is the diffusion coefficient.

Applying the Kruzkov - kinetic theory and the stochastic theory, we establish the existence and uniqueness for a global-in-time stochastic solution of the system (4).

N.V. Chemetov acknowledges support from FAPESP, Grant 2021/03758-8.

Joint work with Fernanda Cipriano (New University of Lisbon, Portugal).

References:

[1] L. K. Arruda, N. V. Chemetov, F. Cipriano, *Solvability of the Stochastic Degasperis-Procesi Equation.* J. Dynamics and Differential Equations, (2021), 1-20.

[2] N. V. Chemetov, F. Cipriano, *Weak kinetic solution for Stochastic Degasperis-Procesi Equation.* To be submitted.

Predator-prey and epidemiology models using transport equations

Paulo Amorim, Carlota Rebelo, Alessandro Margheri
Universidade Federal do Rio de Janeiro

We will present and analyze a predator-prey model in which the predator has a hunger structure. The model takes the form of a transport equation with non-local terms, coupled to an ODE for the prey. We show well-posedness and asymptotic results, simulations, and applications. Using a similar method, we present an epidemiological transport equation model in which the healthy population is structured by susceptibility and disease awareness. We analyze the stability properties of an ODE system obtained for the integral quantities of the transport equation. We present simulations and applications.

On the Riemann problem for for a generalized zero-pressure gas dynamics system with linear damping

Richard De la cruz, Juan Juajibioy
Universidad Pedagógica y Tecnológica de Colombia

In this talk, we study the Riemann problem for a generalized zero-pressure gas dynamics system with linear damping,

$$\begin{cases} \rho_t + (\rho u^k)_x = 0, \\ (\rho u)_t + (\rho u^{k+1})_x = -\alpha \rho u, \end{cases} \tag{5}$$

where k is an odd natural number and $\alpha > 0$ is a constant. When $k = 1$ and $\alpha = 0$, the system has been extensively studied (see Bouchut [1], E, Rykov, and Sinai [2], Huang and Wang [3], LeVeque [4], and its references for further details).

In this talk, we show that the system (5) has two kind solutions: contact discontinuities and delta shock. Also, we propose a time-dependent viscous system and by using the vanishing viscosity method we show the existence of delta shock solutions for the system.

References:

[1] F. Bouchut. On zero pressxure gas dynamics. *Advances in kinetic theory and computing*. Series on Advances in Mathematics for Applied Sciences 22, Singapore: World Scientific. 1994; pp. 171–190.

[2] Weinan E., Yu. G. Rykov, Ya. Sinai. Generalized variational principles, global weak solutions and behavior with random initial data for systems of conservation laws arising in adhesion particle dynamics, *Commun. Math. Phys.* 1996; 177: 349–380.

[3] F. Huang, Z. Wang. Well posedness for pressureless flow, *Commun. Math. Phys.* 2001; 222: 117–146.

[4] R. J LeVeque . The dynamics of pressureless dust clouds and delta waves, *J. Hyperbolic Differ. Equ.* 2004; 1(2): 315–327.

Elliptic Equations

Organizer: Ederson Moreira dos Santos (USP/Brazil) & Marcos T. O. Pimenta (UNESP/Brazil)

Solutions for an Euclidean Bosonic Equation via variational and bifurcation methods

Alânnio B. Nóbrega, Francisco J. S. A. Corrêa, Alannio B. Nóbrega, Leandro S. Tavares
Universidade Federal de Campina Grande

This paper concerns with the study of existence and multiplicity of solution for following class of nonlocal problems which arise in recent developments in the mathematical physics of string theory and cosmology given by

$$\begin{cases} -\Delta e^{-c\Delta}u + u = \lambda P(x)(u + f(x,u)), \text{ in } \mathbb{R}^N \\ \lim_{|x|\to\infty} u(x) = 0, \quad u \in \mathcal{H}^{c,\infty}(\boldsymbol{R}^N), \end{cases} \tag{P}$$

where $N \geq 3$, $c > 0$, $\lambda > 0$, $P : \mathbb{R}^N \to \mathbb{R}$ is a positive continuous function, $f : \mathbb{R}^N \times \mathbb{R} \to \mathbb{R}$ is C^1-function, $e^{-c\Delta}$ is defined via a power series and $\mathcal{H}^{c,\infty}(\boldsymbol{R}^N)$ is a Hilbert space as introduced by Gorka, Prado and Reyes. The main tools used here is the Minimax Theorems and a bifurcation result via variational methods due to Rabinowitz.

The first eigenvalue of the 3D Stokes eigenvalue problem under Navier boundary conditions

Alessio Falocchi, Filippo Gazzola
Politecnico di Milano

We study the Stokes eigenvalue problem under Navier boundary conditions in $C^{1,1}$-domains $\Omega \subset \mathbb{R}^3$. Differently from the Dirichlet boundary conditions, zero may be the least eigenvalue. We fully characterize the domains where this happens and we show that the ball is the unique domain where the zero eigenvalue is not simple, it has multiplicity three. We apply these results to show the validity/failure of a suitable Poincaré inequality. The proofs are obtained by combining analytic and geometric arguments.

An explicit threshold for the appearance of lift on the deck of a bridge

Clara Patriarca, Filippo Gazzola
Politecnico di Torino

We set up the analytical framework for studying the threshold for the appearance of a *lift force* exerted by a viscous steady fluid (the wind) on the deck of a bridge. We model this interaction as in a wind tunnel experiment, where at the inlet and outlet sections the velocity field of the fluid has a *Poiseuille flow* profile. Since in a symmetric configuration the appearance of lift forces is a consequence of non-uniqueness of solutions, we compute an explicit threshold on the incoming flow ensuring uniqueness. This requires building an explicit solenoidal extension of the prescribed Poiseuille flow and bounding some embedding and cutoff constants. This is a joint work with Professor Filippo Gazzola.

On existence of multiple normalized solutions to a class of elliptic problems in whole $\mathbb{R}^N$ via penalization method

Claudianor Oliveira Alves, Nguyen Van Thin
Universidade Federal de Campina Grande

In this paper we study the existence of multiple normalized solutions to the following class of elliptic problems

$$\begin{cases} -\epsilon^2\Delta u + V(x)u = \lambda u + f(u), & \text{in } \mathbb{R}^N, \\ \int_{\mathbb{R}^N} |u|^2 dx = a^2\epsilon^N, \end{cases}$$

where $a, \epsilon > 0$, $\lambda \in \mathbb{R}$ is an unknown parameter that appears as a Lagrange multiplier, $V : \mathbb{R}^N \to [0, \infty)$ is a continuous function, and f is a continuous function with L^2-subcritical growth. It is proved that the numbers of normalized solutions are related to the topological richness of the set where the potential V attains its minimum value in a bounded set $\Lambda \subset \mathbb{R}^N$. In the proof our main result, we apply minimization techniques, Lusternik-Schnirelmann category and the penalization method found in del Pino and Felmer.

Radial solvability for Lane-Emden type systems in annuli

Gabrielle Nornberg
Universidad de Chile

In this talk we discuss some recent results on the existence of positive radial solutions defined in annuli for Lane-Emden type systems involving Pucci extremal operators.

The method of the energy function and applications

João Rodrigues dos Santos Júnior
Universidade Federal do Pará

In this work, we establish a new method to find critical points of differentiable functionals defined in reflexive Banach spaces, which belong to an appropriated class ($\mathcal{J}$) of functionals. More specifically, once given a functional J in the class ($\mathcal{J}$), the central idea of the referred method consists in defining a suitable real function ζ of a real variable, called energy function, which is naturally associated to J in the sense that the existence of real critical points for ζ guarantees the existence of critical points for the functional J. As a consequence, we solve some variational elliptic problems, whose associated energy functional belongs to ($\mathcal{J}$) and provide a version of the mountain pass theorem for functionals in the class ($\mathcal{J}$).

Energy Estimates for Seminodal Solutions to an Elliptic System with Mixed Couplings

Mayra Soares, Mónica Clapp
Universidade Federal de Goiás

We study the system of semilinear elliptic equations

$$-\Delta u_i + u_i = \sum_{j=1}^{\ell} \beta_{ij}|u_j|^p|u_i|^{p-2}u_i, \qquad u_i \in H^1(\mathbb{R}^N), \qquad i = 1, \dots, \ell,$$

where $N \geq 4$, $1 < p < \frac{N}{N-2}$, and the matrix (β_{ij}) is symmetric and admits a block decomposition such that the entries within each block are positive or zero and all other entries are negative.

We provide simple conditions on (β_{ij}), which guarantee the existence of fully nontrivial solutions, i.e., solutions all of whose components are nontrivial.

We establish existence of fully nontrivial solutions to the system having a prescribed combination of positive and nonradial sign-changing components, and we give an upper bound for their energy when the system has at most two blocks.

We derive the existence of solutions with positive and nonradial sign-changing components to the system of singularly perturbed elliptic equations

$$-\varepsilon^2 \Delta u_i + u_i = \sum_{j=1}^{\ell} \beta_{ij} |u_j|^p |u_i|^{p-2} u_i, \qquad u_i \in H_0^1(B_1(0)), \qquad i = 1, \ldots, \ell,$$

in the unit ball, exhibiting two different kinds of asymptotic behavior: solutions whose components decouple as $\varepsilon \to 0$, and solutions whose components remain coupled all the way up to their limit.

References:

[1] T-C. Lin, J. Wei. Ground state of N coupled nonlinear Schrödinger equations in $\mathbb{R}^n$, $n \leq 3$. *Comm. Math. Phys.* 255 (2005), no. 3, 629-653.

[2] M. Clapp, P. N. Srikanth. Entire nodal solutions of a semilinear elliptic equation and their effect on concentration phenomena. *J. Math. Anal. Appl.* 437 (2016), no. 1, 485-497.

[3] M. Clapp, M. Soares. Coupled and uncoupled sign-changing spikes of singularly perturbed elliptic systems. *Communication in Contemporary Mathematics*, to appear. arXiv:2108.00299.

[4] M. Clapp, A. Pistoia. Fully nontrivial solutions to elliptic systems with mixed couplings. *Nonlinear Analysis* 216 (2022), 112694.

On existence and nonexistence results for a class of hamiltonian Choquard type systems with lower critical growth in $\mathbb{R}^2$

Olimpio Hiroshi Miyagaki, Braulio Maia
Universidade Federal de São Carlos

First, we investigate the nonexistence of classical nontrivial solutions for a class of Hamiltonian-Choquard-type elliptic systems

$$\begin{cases} -\Delta u + u = (I_\alpha * |v|^p)\, v^{p-1} \text{ in } \mathbb{R}^N, \\ -\Delta v + v = (I_\beta * |u|^q)\, u^{q-1} \text{ in } \mathbb{R}^N, \\ u(x), v(x) \to 0 \text{ when } |x| \to \infty, \end{cases}$$

when

$$(N+\alpha)/p + (N+\beta)/q \leq 2(N-2), \text{ (if } N \geq 3)$$

and

$$(N+\alpha)/p + (N+\beta)/q \geq 2N \quad (\text{if} N = 2),$$

where I_α and I_β denote the Riesz potential.

Second, via variational methods and the generalized Nehari manifold, we show the existence of a nontrivial non-negative solution or a Nehari-type ground state solution for the problem

$$\begin{cases} -\Delta u + u = (I_\alpha * |v|^{\frac{\alpha}{2}+1})|v|^{\frac{\alpha}{2}-1}v + g(v) \text{ in } \mathbb{R}^2, \\ -\Delta v + v = (I_\beta * |u|^{\frac{\beta}{2}+1})|u|^{\frac{\beta}{2}-1}u + f(u), \text{ in } \mathbb{R}^2, \\ u, v \in H^1(\mathbb{R}^2), \end{cases}$$

where $\alpha, \beta \in (0,2)$ and f, g have exponential critical growth in the Trudinger-Moser sense.

Regularity theory for optimal partition problems with volume constraints

Pêdra Andrade, Ederson Moreira dos Santos (ICMC - USP), Makson Santos (IST- ULisboa), Hugo Tavares (IST - ULisboa)
Instituto Superior Técnico - ULisboa

We examine a class of optimal partition problems with volume constraints. We show the existence of the optimal partition by using a weak formulation that involves a minimization problem where the variables are functions rather than domains. Then, we also prove that the minimizers are locally Lipschitz continuous.

Signed radial solutions for phi-Laplacian problems

Sigifredo Herrón Osorio, Emer Lopera Arias, Diana Sánchez Monsalve
Universidad Nacional de Colombia Sede Medellín

In this talk we socialize results of the existence of positive radial solutions for a general problem involving ϕ-Laplacian. The main tool is a technique of ordinary differential equations, which is called as shooting. The non-linearity satisfies suitable conditions and has a semipositone type behavior. Namely, we consider problems of the form

$$-\Delta_\phi u = \lambda f(u) = 0 \quad \text{in } \Omega, \quad u = 0 \quad \text{on } \partial\Omega,$$

where Ω is the unit ball in $\mathbb{R}^N$ with $N > 1$ and $\lambda > 0$ is a parameter. The differential operator Δ_ϕ is called ϕ-Laplacian, which is defined as

$$\Delta_\phi u = \operatorname{div}\big(\phi(|\nabla u|)\nabla u\big).$$

Finally, $\phi\colon \mathbb{R} \to [0,\infty)$ is an even and continuous function that is differentiable outside the origin and it is increasing in $(0,\infty)$.

This talk is based in a joint work with Emer Lopera and Diana Sánchez.

References:

[1] C. O. Alves, A. R. F. de Holanda, J. Santos. Existence of positive solutions for a class of semipositone quasilinear problems through Orlicz-Sobolev space. *Proc. Am. Math. Soc.* 147 (1) (2019), 285-299.

[2] S. Herrón, D. Sánchez, E. Lopera. Positive solutions for a semipositone ϕ-Laplacian problem. *J. Math. Anal. Appl.* 510 (2022), no. 2, Paper No. 126042, 17 pp.

[3] S. Herrón and E. Lopera. Signed Radial Solutions for a Weighted p-Superlinear Problem, *Electronic Journal of Differential Equations* 24 (2014), 1-13.

[4] N. Kawano, W.M. Ni, S. Yotsutani A generalized Pohozaev identity and its applications. *J. Math. Soc. Jpn.* 42 (3) (1990), 541-564.

[5] W. Reichel, W. Walter. Radial solutions of equations and inequalities involving the p-Laplacian. *J. Inequal. Appl.* (1997), 47-71.

Free Boundaries Problems and Related Topics

Organizer: João Vitor da Silva (UNICAMP/Brazil), Disson dos Prazeres (UFS/Brazil) & Mariana Smit Vega Garcia (WWU/USA)

Improved regularity estimates for degenerate fully nonlinear elliptic equations

Damiao J. Araujo, Boyan Sirakov
Universidade Federal da Paraíba

We will discuss interior versus boundary regularity estimates of viscosity solutions to degenerate fully nonlinear elliptic PDEs. We will be interested in showing how precisely the smoothness, of a given solution, is affected by its degenerate diffusion model and boundary datum.

Up to the boundary gradient estimates in Bernoulli type free boundary problems

Diego Moreira
Universidade Federal do Ceará

In this talk, we discuss recent advances on up to the boundary gradient estimates for viscosity solutions of free boundary problems governed by fully nonlinear and quasilinear equations with unbounded coefficients. We present the new Inhomogeneous Pucci Barriers as new elements for the proof. If time permits, we discuss some of the main steps in the proof, namely, the trace estimate of the solution on the points of the fixed boundary that projects nontangentially over the free boundary. These methods are inspired by some ideas of Carlos Kenig in Harmonic Analysis.

Rigorous thin film approximations of the one-phase unstable Muskat problem

Edoardo Bocchi, Francisco Gancedo
Politecnico di Milano

In this talk we address the one-phase Muskat problem driven by gravity and surface tension. The regime considered is unstable with the fluid on top of a dry region. By a novel approach using a depth-averaged formulation, we derive two asymptotic approximations for this scenario. The lower order approximation is the classical thin film equation, while the higher order approximation provides a new refined thin film equation. We prove the optimal order of convergence in the shallowness parameter to the original Muskat solutions for both models with low-regular initial data.

On the Bernoulli problem with infinite jumps

Eduardo V. Teixeira, Stanley Snelson
University of Central Florida

We investigate Bernoulli free boundary problems prescribing infinite jump conditions. The mathematical set-up leads to the analysis of non-differentiable minimization problems of the form

$$\int \left(\nabla u \cdot (A(x)\nabla u) + \varphi(x) 1_{\{u>0\}}\right) \mathrm{d}x \to \min,$$

where $A(x)$ is an elliptic matrix with bounded, measurable coefficients and φ is not necessarily locally bounded. We prove universal Hölder continuity of minimizers for the one- and two-phase problems. Sharp regularity estimates along the free boundary are also obtained. Furthermore, we perform a thorough analysis of the geometry of the free boundary around a point ξ of infinite jump, $\xi \in \varphi^{-1}(\infty)$. We show that it is determined by the blow-up rate of φ near ξ and we obtain an analytical description of such cusp geometries.

A transmition problem for first and second order operators

Hector Chang-Lara, Arturo Arellano (McGill)
Centro de Investigación en Matemáticas

Let $\Omega \subset \mathbb{R}^n$ be a bounded domain with Lipschitz boundary and let $\Omega_+ \subset \Omega$ be a sub-domain with the exterior ball property. We establish existence and uniqueness of viscosity solutions for a class of transmission problems governed by elliptic and eikonal type equations in Ω_+ and $\Omega_- := \Omega \setminus \Omega_+$ respectively. The main motivation is the Hamilton-Jacobi equation that results of the following optimal control problem: The goal is to minimize the expected time a particle takes from some initial position $x \in \Omega$ until it exits Ω for the first time. The controller is allowed to choose at each moment the direction that the particle takes whenever this is in the region Ω_-, being the speed equal to one. Over Ω_+ the particle performs instead a Brownian motion.

The Bernstein Problem for One Phase Free Boundary Problems

Hui Yu, Max Engelstein, Xavier Fernandez-Real
National University of Singapore

For the one-phase Bernoulli problem, in the classical case and the thin case, we show that in low dimensions graphical free boundaries are flat.

A free boundary problem with subcritical exponents in Orlicz spaces

Leandro S. Tavares, Jun Zheng
Universidade Federal do Cariri

Given certain functions φ, q, h and a nonnegative constant λ, we consider in this presentation regularity results for the free boundary problem

$$\mathcal{J}(u) = \int_\Omega (G(|\nabla u|) + qF(u^+) + hu + \lambda \chi_{\{u>0\}}) \mathrm{d}x \to \min,$$

over the set $\{u \in W^{1,G}(\Omega) : u - \varphi \in W_0^{1,G}(\Omega)\}$ in the setting of Orlicz spaces, where the functions G and F satisfy the structural conditions of Tolksdorf's type. Moreover, F allows for subcritical exponents. Our mais results are

(i) the local $C^{1,\alpha}$- and Log-Lipschitz continuities of minimizers in the subcritical case for $\lambda = 0$ and $\lambda \geq 0$, respectively;

(ii) the growth rates near the free boundary for non-negative minimizers in the subcritical case for $\lambda \geq 0$, which gives the optimal growth rates of non-negative minimizers for the p-Laplacian problems;

(iii) the local Lipschitz continuity of non-negative minimizers for $\lambda > 0$ under the natural growth condition that $F(t) \lesssim 1 + G(t)$ for $t \geq 0$.

All the results presented in this paper are new even for the free boundary problems of p-Laplacian. This work was done in collaboration with Jun Zheng (Southwest Jiaotong University).

Branch points for (almost-)minimizers of two-phase free boundary problems

Mariana Smit Vega Garcia, Guy David, Max Engelstein, Tatiana Toro
Western Washington University

In this talk, we will discuss minimizers and almost-minimizers of Alt-Caffarelli-Friedman-type functionals. In particular, we will consider branch points in their free boundary.

Regularity estimates for fully nonlinear mean-field games with free boundaries

Pêdra Andrade, Julio Correa-Hoyos (UERJ)
Instituto Superior Técnico - Universidade de Lisboa

I will discuss regularity estimates for fully nonlinear mean-field games associated with free boundaries. We establish improved regularity for the solutions in Sobolev spaces. In addition, we prove the existence of minimizers for the variational problem and the existence of solutions to the mean-field games system. This is joint work with Julio Correa-Hoyo.

Integral and Functional Differential Equations

Organizer: Pierluigi Benevieri (USP/Brazil), Everaldo de Mello Bonotto (USP/Brazil) & Jaqueline G. Mesquita (UnB/Brazil)

Exponential dichotomy for periodic GLDEs

Claudio A. Gallegos, Gonzalo Robledo
Universidad de Chile

In this talk, we are interested in discussing the property of exponential dichotomy (ED) for periodic generalized linear differential equations (GLDEs). To this end, we recall the ED property and the Floquet theory in the generalized framework [1,2]. We propose a characterisation to the property of dichotomy for periodic GLDEs and a simple application to an admisibility result considering periodic components.

This research was supported by ANID/FONDECYT postdoctorado No 3220147.

References:

[1] E. M. Bonotto, M. Federson, F. L. Santos (2018). Dichotomies for generalized ordinary differential equations and applications. *J. Differential Equations*, 264, 3131–3173.

[2] Š. Schwabik (1973). Floquetova teorie pro zobecněné diferenciální rovnice. Časopis pěst. mat. 98, 416–418.

Boundary value problems for generalized ODEs

Everaldo de Mello Bonotto
Universidade de São Paulo

In this talk I will present the existence and uniqueness of solutions of the following boundary value problem concerning generalized ODEs

$$\begin{cases} \dfrac{dx}{d\tau} = D[A(t)x + F(t)], \\ \displaystyle\int_a^b d[K(s)]x(s) = r, \end{cases}$$

for operators taking values in general Banach spaces. Moreover, necessary and sufficient conditions are established not only for the existence of at least one solution, but also for the uniqueness of a solution. Another important result that will be presented describes the solution of the previous BVP in terms of a Green function and the fundamental operator of the corresponding homogeneous problem.

Lyapunov Techniques for integral equations in the sense of Kurzweil

Fernanda Andrade da Silva, Eduard Toon
Universidade de São Paulo

we are interested in investigating stability results for integral equations whose functions involved are Kurzweil integrable.

Time-varying chemostat with pointwise delay: stability analysis

Gonzalo Robledo, Frederic Mazenc, Daniel Sepulveda
Universidad de Chile

This work revisits a recently introduced chemostat model of one–species with a ω–periodic input of single nutrient, which is described by a system of delay differential equations. The previous results provided sufficient conditions ensuring the existence and uniqueness of an ω–periodic solution for delays arbitrarily small. This work partially extends these results by proving –with the construction of Lyapunov like functions– that the above periodic solution is globally asymptotically stable when considering Monod uptake functions and a particular family of nutrient inputs.

Variation of constants formula for delay differential equations: Revisited

Junya Nishiguchi
Tohoku University

The method and the formula of variation of constants for ordinary differential equations (ODEs) is a fundamental tool to analyze the dynamics of an ODE near an equilibrium. It is natural to expect that such a formula works for delay differential equations (DDEs), however, it is well-known that there is a conceptual difficulty in the formula for DDEs. In this talk, we discuss the variation of constants formula for DDEs by introducing the notion of a *mild solution*, which is a solution under an initial condition having a discontinuous history function. Then the *principal fundamental matrix solution* is defined as a matrix-valued mild solution, and we obtain the variation of constants formula with this function. This is also obtained in the framework of a Volterra convolution integral equation, but the treatment here gives an understanding in its own right. We also apply the formula to show the principle of linearized stability and the Poincaré-Lyapunov theorem for DDEs, where we do not need to assume the uniqueness of a solution.

On autonomous and non-autonomous attractors for Lotka-Volterra systems

Piotr Kalita, Jose Antonio Langa, Juan Garcia-Fuentes, Antonio Suarez, Pablo Almaraz
Jagiellonian University

The talk will be devoted to Lotka-Volterra systems: ODE models used in ecology to represent the dynamics of populations. We will discuss the structure of autonomous and non-autonomous attractors for associated problems. For the autonomous case, assuming that the matrix of the system is Volterra-Lyapunov stable, basing on the recent results of Hofbauer and Schreiber, we present an explicit algorithm that allows to construct the graph wich exactly represents the structure of the global attractor. We also show the structural stability result, although the system is not necessarily Morse-Smale. For the non-autonomous case we provide the conditions on time dependent parameters of the model which allow us to determine the full structure of non-autonomous attractors in the cases of 2 and 3 species and various cases of survival and extinction.

On almost periodic solutions for a model of hematopoiesis with an oscillatory circulation loss rate

Rocio Balderrama
Universidad de Buenos Aires

The following nonlinear autonomous delay differential equation was proposed by Mackey and Glass to describe the regulation of hematopoiesis, namely,

$$\frac{dP(t)}{dt} = \frac{\lambda\theta^n P(t-\tau)}{\theta^n + P^n(t-\tau)} - \gamma P(t) \qquad \text{where } \lambda, \theta, n, \gamma, \tau \in (0, +\infty). \quad (1) \tag{6}$$

Here $P(t)$ is the concentration of cells in the circulating blood and the flux function $f(v) = \frac{\lambda\theta^n v}{\theta^n + v^n}$ of cells into the blood stream from the stem cell compartment depends on the cell concentration at an earlier time. The delay τ describes the time between the start of cellular production in the bone marrow and their maturation for release in circulating bloodstream. It is assumed that the cells are lost at a rate proportional to their concentration, namely $\gamma P(t)$.

In the real-world phenomena, the environment varies with time. Thus, the following nonautonomous nonlinear delay differential equation with time-varying coefficients and delays, and oscillatory circulation loss rate is a natural extensions of (1)

$$x'(t) = \sum_{k=1}^{M} \lambda_k r_k(t) \frac{x^m(t-\tau_k(t))}{1 + x^n(t-\tau_k(t))} - b(t)x(t), \quad (2) \tag{7}$$

where $m \geq 0$, $n, \lambda_k > 0$, $b(t), r_k, \tau_k$ are positive almost periodic functions for $k = 1, 2, \ldots, M$ and $b(t)$ is oscillating. The function $\lambda_k r_k(t) \frac{x^m(t-\tau_k(t))}{1+x^n(t-\tau_k(t))}$ is the flux of cells into the blood stream from the $i-th$ stem cell compartment.

In this work, we establish and prove a fixed point theorem from which some sufficient conditions are deduced on the existence of positive almost periodic solutions for (2). Some particular conditions under the nonlinearity of the equation have been previously considered by authors as fundamental assumption for the study of almost periodic solutions of the model. The aim of this work is to establish results without such assumption. Some examples are given to illustrate our results.

Global dynamics for nonautonomous delayed differential systems

Teresa Faria
University of Lisbon

Sufficient conditions for the persistence and permanence of a family of nonautonomous systems of delay differential equations are obtained. This family includes structured systems inspired in mathematical biology models, with either discrete or distributed delays in both the linear and nonlinear terms, and where typically the nonlinear terms are nonmonotone. The criteria depend both on the stability of the linear part and the specific nonlinear terms. By refining the assumptions for permanence, for some concrete models criteria for their global exponential stability are provided. Applications are given.

Stochastic Fractional Non-Local Diffusion Lattice Model with Delays

Xiaoying Han, Yejuan Wang, Yu Wang, Peter Kloeden
Auburn University

A two-dimensional stochastic non-local delay diffusion lattice system with a time Caupto fractional operator of order $\alpha \in (1/2, 1)$ is considered. In particular, the well-posedness, regularity, and general stability of solutions in L^p spaces for $p \geq 2$ will be discussed.

Linear Equations

Organizer: Igor A. Ferra (UFABC/Brazil) & Bruno de Lessa Victor (USP/Brazil)

Global ultradifferentiable properties for certain linear operators on compact manifolds

Fernando de Ávila Silva
Universidade Federal do Paraná

In this talk, we present the study of global hypoellipticity and global solvability for certain linear operators in Komatsu classes of Roumieu and Beurling type on compact manifolds. We exhibit an approach by combining a characterization of these spaces via eigenfunction expansions, generated by an elliptic operator, and the analysis of matrix-symbols obtained by these expansions. This is joint work with Eliakim Cleyton Machado, UFPR-Brazil.

Class of hypocomplex structures on the two dimensional torus

Giuliano Angelo Zugliani, Abdelhamid Meziani
Universidade Estadual de Campinas

Here we deal with Hölder solvability involving a class of complex vector fields on the two-dimensional torus $\mathbb{T}^2$. We make use of a first integral, and a Cauchy-Pompeiu type integral operator as well, on $\mathbb{R}^2$. We also deduce a similarity principle for the solutions to the equation $Lu = au + b\bar{u}$.

This is a joint work with Abdelhamid Meziani from FIU. We thank FAPESP for the financial support.

Maximal L^p estimates for Kohn Laplacian operator on non pseudoconvex CR manifolds of hypersurface type

Joel Coacalle
Universidade de São Paulo

In this work we show subelliptic estimates, and as an application the maximal L^p estimates, for the Kohn Laplacian operator $\Box_b$ at some fixed level of $(0,q)$-forms of the $\bar{\partial}_b$-complex associated to a non pseudoconvex CR manifolds of hypersurface type M. The type of CR manifolds we consider are weak $Y(q)$ manifolds, where we consider the finite commutator property. Here we introduce a weaker version of the well known hypothesis $D(q)$ adapted for the weak $Y(q)$ case, which is a condition that compares sum of q eigenvalues of the Levi matrix in M. We show that these two conditions, finite type and the adapted $D(q)$ condition, are sufficient to show subelliptic estimates at some specific level of $(0,q)$-forms, using a microlocal argument. The subselliptic estimates allow us analyze the distributional kernels of the complex Green Operator and the Szegö projection. Using an appropiate singular integral operator we derive maximal L^p estimates for $\Box_b$.

Hypoellipcity for pairs of spaces

Luis Fernando Ragognette, Bruno de Lessa Victor
Universidade Federal de Minas Gerais

Consider a differential operator P with real-analytic coefficients. Let $\mathcal{F}$ and $\mathcal{G}$ be two subsheaves of the sheaf of hyperfunctions over $\mathbb{R}^N$. Assume that that $\mathcal{G}$ is a subsheaf of $\mathcal{F}$ and that P induces an automorphism in $\mathcal{F}$ and also in $\mathcal{G}$, then we can define the notion of hypoellipticity of P with respect the pair $(\mathcal{F},\mathcal{G})$ as follows: given U an open subset of $\mathbb{R}^N$ we have that if $u \in \mathcal{F}(U)$ is such that $Pu \in \mathcal{G}(U)$, then u is perforce an element of $\mathcal{G}(U)$. For instance, we usually say that P is hypoelliptic if it is hypoelliptic with respect to the pair $(\mathcal{D}',\mathcal{C}^\infty)$ and P is analytic-hypoelliptic if it is hypoelliptic with respect to the pair $(\mathcal{D}',\mathcal{C}^\omega)$.

In a joint work with Bruno de Lessa Victor, we investigate when hypoellipticity with respect to a pair of spaces is equivalent to hypoellipticity with respect to another pair. This question was motivated by a work of Cordaro and Hanges where they proved for a class of differential operators that analytic-hypoellipticity can be extended from distributions to hyperfunctions.

An Abstract lagrangian framework for computing shape derivatives

Pedro T. P. Lopes, Antoine Laurain, Jean C. Nakasato
Universidade de São Paulo

We present the results of a recent paper, in which we study an abstract framework for computing shape derivatives of functionals subject to PDE constraints.

We develop this abstract framework using implicit function theorem. It yields practical formulae to compute the derivative of a shape functional, the material derivative of the state and the adjoint state. Applications in linear elliptic, nonlinear elliptic, parabolic PDEs and distributions will be presented.

Pedro T. P. Lopes was partially supported by grant 2019/15200-1, São Paulo Research Foundation (FAPESP).

Characterization of ultradifferentiable functions via a class of FBI transforms

Renan Dantas Medrado
Universidade Federal de Alagoas

We present a class of FBI transforms using weight functions (which includes the class of FBI transforms presented by M. Christ in 1997) and characterize Braun, Meise and Taylor (BMT) locally regularity of ultradistributions via this class. Also, we characterize the BMT vectors (defined by a hypoelliptic operator of constant coefficient) in terms of the class of FBI transform. As an application we prove that for elliptic constant coefficient operators the class of BMT functions is equal the class of BMT vectors.

The Metivier inequality and ultradifferentiable hypoellipticity

Stefan Fürdös, Paulo Cordaro
Universidade de Sao Paulo

1980 Metivier showed that a differential operator P with L^2 right inverse and analytic coefficients is analytic hypoelliptic at a point if and only if there is an a-priori estimate for P involving a weighted

Sobolev norm, the so-called Metivier inequality. In this talk we extend Metivier's statement from the analytic category to the ultradifferentiable category. More precisely, if P is a differential operator with an L^2 right inverse and coefficients in a Denjoy-Carleman class $\mathcal{E}^{\{\mathbf{M}\}}$ then P is $\{\mathbf{M}\}$-hypoelliptic at a point if and only if P satisfies a generalized Metivier inequality. We might note that the Denjoy-Carleman class $\mathcal{E}^{\{\mathbf{M}\}}$ in the statement above might be quasi-analytic or non-quasianalytic.

This is joint work with Paulo Cordaro from the University of Sao Paulo.

Necessary cancellation conditions for the boundedness of operators on local Hardy spaces

Tiago Picon
Universidade de São Paulo

In this talk we present necessary cancellation conditions for the continuity of linear operators in $h^p(\mathbb{R}^n)$, $0 < p \leq 1$, that map atoms into pseudo-molecules. As application, we present necessary and sufficient cancellation condition for the boundedness of inhomogeneous Calderón–Zygmund type operators. This is joint work with Galia Dafni and Chun Ho Lau (Concordia University, Canada) and Claudio Vasconcelos (UFSCar, Brazil).

Subelliptic Komatsu Classes on Manifolds

Wagner Augusto Almeida de Moraes
Universidade Federal do Paraná

In this work, inspired by the paper [1], we define and study Komatsu classes associated with a Hörmander family of globally defined vector fields and its corresponding sub-Laplacian. We show some relations between the various Komatsu classes in this setting on general manifolds. We also define the notion of global hypoellipticity in this setting and present some results when the manifold is a compact Lie group.

References:

[1] V. Fischer, M. Ruzhansky, C. A. Taranto. Subelliptic Gevrey spaces. *Math. Nachr.*, 294 (2), 265-285 (2021).

Multiscale Dynamics

Organizer: Yao Li (UMass Amherst/USA) & Zhongwei Shen (UAlberta/Canada)

Solving non-Markovian Stochastic Control Problems driven by Wiener Functionals

Alberto Ohashi
Universidade de Brasília

In this talk, we present a general methodology for stochastic control problems driven by the Brownian motion filtration including non-Markovian and non-semimartingale state processes controlled by mutually singular measures. We will present a numerical scheme for computing near-optimal controls associated with controlled Wiener functionals via a finite-dimensional approximation procedure. The theory does not require functional differentiability assumptions on the value process and ellipticity conditions on the diffusion components. Explicit rates of convergence are provided under rather weak conditions for distinct types of non-Markovian and non-semimartingale states. The analysis is carried out on suitable finite dimensional spaces and it is based on the weak differential structure introduced by the authors in previous works jointly with measurable selection arguments. The theory is applied to stochastic control problems based on path-dependent SDEs and rough stochastic volatility models, where both drift and possibly degenerated diffusion components are controlled. Optimal control of drifts for nonlinear path-dependent SDEs driven by fractional Brownian motion with exponent $H \in (0, \frac{1}{2})$ is also discussed.

Sharp convergence for degenerate Langevin dynamics

Gerardo Barrera Vargas, Conrado da Costa, Milton Jara
University of Helsinki

In this talk, we study an ordinary differential equation with a unique degenerate attractor at the origin, to which we add a white noise with small parameter that regulates the intensity of the noise. Under general conditions, for any fixed intensity, as time tends to infinity, the solution of this stochastic dynamics converges exponentially fast in total variation distance to an equilibrium distribution. We suitable accelerated the random dynamics and show that the preceding convergence occurs in a sharp form, that is, the total variation distance of the accelerated random dynamics and its equilibrium distribution tends to a non-degenerate limiting silhouette, which corresponds to the total variation distance between the marginal of a suitable stochastic differential equation that comes down from infinity and its corresponding equilibrium distribution. The limiting silhouette that arises from this convergence is not a step profile that appears in the cut-off phenomenon for Markov processes.

On a novel mechanism for the generation of Stable Chimera States via Geometric Singular Perturbation Theory

Luis Guillermo Venegas Pineda, Hildeberto Jardón Kojakhmetov, Ming Cao
University of Groningen

Chimera states have attracted substantial attention during the last decades due to their unexpected symmetry broken spatio-temporal nature, allowing the coexistence of synchronous and asynchronous behaviors in complex networks under specific conditions. Although relevant results of such unforeseen

states in different physical and topological configurations have been obtained, there remain several structures and mechanisms yet to be unveiled. In this talk, I will present a novel technique for the generation of stable chimera states by the incorporation of adaptive coupling strengths. For this purpose, we study a multilayer network composed by two populations of heterogeneous Kuramoto phase oscillators with coevolutive couplings only dependent on macroscopic quantities of the system. Given the nature of our model and by considering the thermodynamic limit, we obtain a mean-field representation allowing us to employ Geometric Singular Perturbation Theory (GSPT) with the inclusion of a time-scale separation between the dynamics of the nodes and the evolution of the corresponding coupling. Thereafter, I will address two different problems, namely the coevolutive inter and intra-coupling scenarios, for which we derive necessary and sufficient conditions for the critical manifold to be normally hyperbolic and attracting along the entire domain of interest. Moreover, I will discuss the effect of the selected slow adaptation law in the formation of different synchronization patterns such as stable chimera states and persistent breathing chimeras in the mean-field. Furthermore, considering the previous conditions and the stability of the coupling dynamics, I provide with arguments for the preservation of such behaviors at the network level, supported by numeric results for several synchronization patterns. Finally, we present simulations of the non-hyperbolic case for which relaxation oscillations and canard cycles, related for the first time to breathing chimera states, have been observed.

Stochastic n-point D-bifurcations of stochastic Lévy flows and their complexity on finite spaces

Paulo Henrique da Costa, Michael Hogele, Paulo Ruffino
Universidade de Brasília

This work refines the classical notion of a stochastic D-bifurcation to the respective family of n-point motions for homogeneous Markovian stochastic semiflows, such as stochastic Brownian flows of homeomorphisms, and their generalizations. This notion essentially detects at which level $k \leqslant n$ the support of the invariant measure of the k-point bifurcation has more than one connected component. Stochastic Brownian flows and their invariant measures which were shown by Kunita (1990) to be rigid, in the sense of being uniquely determined by the 1-and 2-point motions, and hence only stochastic n-point bifurcation of level $n = 1$ or $n = 2$ can occur. For general homogeneous stochastic Markov semiflows this turns out to be false. This article constructs minimal examples of where this rigidity is false in general on finite space and studies the complexity of the resulting n-point bifurcations.

An Averaging Principle for Stochastic Flows in Foliated Manifolds

Paulo Ruffino
Universidade Estadual de Campinas

Consider an SDE on a foliated manifold whose trajectories lay on compact leaves. We investigate the effective behaviour of a small transversal perturbation of order ϵ. An average principle is shown to hold such that the component transversal to the leaves converges to the solution of a deterministic ODE, according to the average of the perturbing vector field with respect to invariant measures on the leaves, as ϵ goes to zero. An estimate of the rate of convergence is given. These results generalize the geometrical scope of previous approaches, including completely integrable stochastic Hamiltonian system.

Investigating the shape of high-dimensional landscape via coupling approach

Shirou Wang
Jilin University

Potential functions used in optimizations, dynamics applications, and machine learning etc. can be rather complicated in term of their structures and properties especially in very high dimensions. Due to lacking of knowledge on concrete forms of potential functions in real applications, even the determination of their basic structures and properties is a challenging problem in both mathematical analysis and numerical simulations. This talk presents a probabilistic approach to investigate the landscape of potential functions, including those in high dimensions, by using an appropriate coupling scheme to couple two copies of the overdamped Langevin dynamics of the potential functions. It can be theoretically shown that for potential functions with single or multiple wells, the coupling time distributions admit qualitatively distinct exponential tails in terms of noise magnitudes. In addition, a quantitative characterization of the non-convexity of a multi-well potential function can also be obtained via linear extrapolation. These theoretical findings thus suggest a promising approach to probe the shape of a potential landscape through the coupling time distributions at least numerically. Such a detection approach shares the same spirit with the well-known problem of "Can one hear the shape of a drum?" proposed by Kac in his famous 1966 paper. A variety of numerical examples in different contexts will be demonstrated in the talk, which include potentials arising as the Rosenbrock functions, in interacting particle systems, and in the problem of loss landscapes of neural networks with different sizes. This talk is based on a recent joint work with Yao Li at UMASS and Molei Tao at Georgia Tech.

Noise-induced transient dynamics

Weiwei Qi
University of Alberta

Many complex processes exhibit transient dynamics - intriguing or important dynamical behaviors over a relatively long but finite time period. A fundamental issue is to understand transient dynamics of different mechanisms. In this talk, we focus on a class of randomly perturbed processes arising in chemical reactions and population dynamics where species only persist over finite time periods and go to extinction in the long run. To capture such transient persistent dynamics, we use quasi-stationary distributions (QSDs) and study their noise-vanishing asymptotic. Special attention will be paid to essential differences between models with and without environmental noises. The talk ends up with some discussions.

Multiscale dynamics of Gamma oscillation in neuronal networks

Yao Li
University of Massachusetts Amherst

In this talk I will discuss an interesting slow-fast dynamics called the multi-firing event (MFE), which can occur in many neuronal network models. It is believed that MFEs are responsible for the Gamma oscillation in human brain. The MFE dynamics is very challenging to study because of its high dimensionality, multi-scale, and noisy nature. I will introduce our progress in understanding MFE dynamics in the recent a few years.

Multiscale dynamics in randomly perturbed dynamical systems

Zhongwei Shen
University of Alberta

Randomly perturbed dynamical systems arise from many scientific areas and often have multiple time scales with the most interesting and important dynamical behaviours exhibiting over finite time scales. The main purpose of this talk is to show the roles played by quasi-stationary distributions and spectral properties of the generator in investigating the multiscale dynamics of such systems. A particular attention will be paid to the influence of the dynamics of the unperturbed system.

Nonlinear Dynamical Systems

Organizer: Phillipo Lappicy (UFRJ/Brazil) & Juliana Fernandes da Silva Pimentel (UFRJ/Brazil)

Two types of nonuniform exponential dichotomy and applications to nonautonomous attractors

Alexandre N. Oliveira Sousa, José A. Langa, Rafael Obaya
Universidade Estadual de Campinas

In this work we study nonuniform exponential dichotomies and existence of pullback and forward attractors for evolution processes associated to nonautonomous differential equations. We define a new type of nonuniform exponential dichotomy for which we study the relation with the standard notion and establish robustness under perturbation for it. We provide a dynamical interpretation of admissibility pairs related with exponential dichotomies to obtain existence of pullback and forward attractors. We apply these abstract results to differential equations.

The destabilizing effect of unbalanced reaction as diffusivity decreases on reaction-diffusion equations in boundaryless surfaces.

Arnaldo Simal do Nascimento
Universidade Federal de São Carlos

This is based on a namesake article to appear in SIAM - J. on Mathematical Analysis and is a contribution to unravel the interplay between diffusivity, domain geometry and the reaction term of the reaction-diffusion equation $u_t = \sigma^2 \triangle u + f_\delta(u)$ in $\mathcal{M}$, a surface of revolution without boundary, that impacts the dynamics of the flow.

The focus is on the role played by the breaking of equipartition of energy on existence of stable/unstable stationary solutions.

Indeed if $\mathcal{M}$ has a local isolated minimizing geodesic and f_0 is a bi-stable function with three consecutive zeros $\alpha_0 < 0 < \beta_0$ satisfying $\int_{\alpha_0}^{\beta_0} f_0 = 0$, then there exists a family of stable stationary monotonic solutions for all $0 < \sigma < \sigma_0$ whose limiting amplitude, as $\sigma \to 0$, is $\beta_0 - \alpha_0$. For σ fixed, these stable solutions still persist if f_0 is perturbed to some f_δ whose stable zeros satisfies $\int_{\alpha_0}^{\beta_\delta} f_\delta > 0$.

However as opposed to the case $\delta = 0$ these solutions eventually become unstable as $\sigma \to 0$. This happens as the limiting internal transition layer located at the local minimal geodesic when the equal-area condition is in place shifts, when it breaks, to the most western/eastern end of the surface, as $\sigma \to 0$, thus giving rise to a spiky unstable stationary solution whose height approaches $\mu - \alpha_0$ where μ, $\alpha_0 < 0 < \mu < \beta_0 < \beta_\delta$, realizes, again, $\int_{\alpha_0}^{\mu} f_\delta = 0$.

In particular since this asymptotic behavior does not rely on stability it indicates that the well-known convergence, as $\sigma \to 0$, of the nodal curves of stationary solution to the Allen-Cahn equation, $\sigma^2 \triangle u + u - u^3 = 0$ in $\mathcal{M}$, to the local minimizing geodesic fails under any perturbation of the zeros of $f(u) = u - u^3$ that results in the breaking of the equipartition of energy.

Snaking of time-periodic nonlinear structures

Bjorn Sandstede, Timothy Roberts
Brown University

Spatial patterns arise in many natural processes: buckled shells, spots in autocatalytic chemical reactions, crime hotspots, localized fluid structures, and vegetation spots are prominent examples that have attracted much attention. Motivated by numerical simulations in the Brusselator model of autocatalytic chemical reactions, I will focus here on time-periodic spatial patterns that connect a spatially homogeneous temporal oscillation in the far field with a stationary spatially periodic Turing pattern in their core. Using spatial dynamics, we will demonstrate that these structures exist along intricate bifurcation curves, often generally referred to as snaking curves. We will also prove that these spatially symmetric structures are accompanied by one-parameter families of time-periodic, spatially asymmetric traveling waves that are parametrized by a relative phase: this contrasts sharply with the case of stationary spatial patterns whose accompanying asymmetric structures are isolated. I will also discuss implications for applications and open challenges.

Bifurcation and hyperbolicity of equilibria for a one-dimensional nonlocal quasilinear parabolic problem

Estefani Moraes Moreira, José M. Arrieta, Alexandre N. Carvalho, José Valero
Universidade de São Paulo

In this lecture, we will present a complete characterization of the bifurcation of equilibria for a nonlocal one-dimensional quasilinear parabolic problem. We will construct auxiliary functions whose graphs will give us information on the bifurcation for our problem and the hyperbolicity of equilibria.

Asymptotically autonomous problems with variable exponents

Jacson Simsen
Universidade Federal de Itajubá

In this talk I will present theoretical results in both univalued and multivalued scenario in order to establish convergence in the Hausdorff semi-distance of the component subsets of the pullback attractor of a non-autonomous problem to the global attractor of the corresponding autonomous problem and apply them to Partial Differential Equations and Inclusions with variable exponents.

A degenerate parabolic logistic equation

Juliana Fernandes, Liliane Maia
Universidade Federal do Rio de Janeiro

We will present some recent results on existence and behavior of solutions for a class of semilinear parabolic equations, defined on a bounded smooth domain, with a nonlinear term which is asymptotically linear at infinity, or else for degenerate logistic nonlinearities. Global solutions are obtained and their behavior is analysed when the initial data varies in the phase space. In particular, the so called Nehari manifold is used to separate the phase space into regions of initial data where uniform boundedness or grow-up behavior of the semiflow may occur.

Topological equivalence for Lipschitz perturbations of the Chafee-Infante equation

Leonardo Pires, Leonardo Pires, Matheus C. Bortolan
Universidade Estadual de Ponta Grossa

In this talk we we introduce the notion of *spectral decomposition* for global attractors of gradient semigroups, which allows us to define the concept of *saddles* to non-differentiable semigroups. Using this notion, we exhibit necessary and sufficient conditions to obtain the topological equivalence between two global attractors $\mathcal{A}_1$ and $\mathcal{A}_2$ of gradient semigroups T_1 and T_2, respectively, both having a spectral decomposition. As an application, we show that Lipschitz perturbations of the Chafee-Infante equation produce gradient semigroups with global attractors with spectral decomposition, and that are topologically equivalent to the unperturbed attractor.

References:

[1] M. C. Bortolan, C. A. E. N. Cardoso, A. N. Carvalho, L. Pires. Lipschitz perturbations of Morse-Smale semigroups. *Journal of differential equations*, 269, 1904-1943, 2020.

[2] L. Pires. Lipschitz perturbations of the Chafee-Infante equation. *Journal Mathematical Analysis and Applications*, 519, 2023.

[3] M. C Bortolan, L. Pires. Topological equivalence of global attractors for Lipschitz perturbations of the Chafee-Infante equation. Preprint.

Weak global attractor for the 3D Navier Stokes equations

Matheus Cheque Bortolan, Alexandre Nolasco de Carvalho, Pedro Marín-Rubio, José Valero
Universidade Federal de Santa Catarina

In [1] the authors prove the well-posedness for the family of *globally modified* $3D$ *Navier-Stokes equations* (GMSNE), indexed in a parameter $N > 0$, via Galerkin method, and obtain the existence of an absorbing set (uniform with respect to N). Furthermore, they obtain the existence of a compact global attractor for each $N > 0$ fixed.

Following their ideas, by modifying a little the GMNSE we are able to obtain the well-posedness of this new family of equations by using the ϵ*-regularity theory*, presented in [2]. Using a limiting process when $N \to \infty$, we are able to define an object $\mathcal{A}$ that is, in some sense, a *weak global attractor* for the $3D$ Navier-Stokes equation (NSE), that is, $\mathcal{A}$ is weakly compact, attracts a particular class of solutions of the NSE (which we call $\mathcal{KN}$) in the weak topology, and has an invariance property. We can also prove that in this attractor, $\mathcal{KN}$ generates a multivalued semiflow.

This is a joint work with Alexandre Nolasco de Carvalho (ICMC-USP), Pedro Marín-Rubio (Universidad de Sevilla) and José Valero (Universidad Miguel Hernández de Elche).

References:

[1] J. M. Arrieta and A. N. Carvalho. Abstract parabolic problems with critical nonlinearities and applications to Navier-Stokes and heat equations. *Trans. Amer. Math. Soc.*, 352(1):285-310, 2000.

[2] T. Caraballo, J. Real, and P. E. Kloeden. Unique strong solutions and V- attractors of a three dimensional system of globally modified Navier-Stokes equations. *Adv. Nonlinear Stud.*, 6(3), 411-436, 2006.

Curvature-type diffusions and wave fronts: some recent results

Maurizio Garrione
Politecnico di Milano

We present some recent results regarding existence and asymptotic behavior (for vanishing diffusion) of critical wave fronts for reaction-diffusion models with curvature-type diffusive term, both in the Euclidean and in the Lorentz space. In the former case, we prove that the critical front may become steady and discontinuous for sufficiently small values of the parameter, converging then to the usual stepwise limit. In the latter case, we show the onset of the new phenomenon of one-sided sharpening of the limit front profile. The technique relies on the analysis of a suitable associated first-order reduction via shooting-type arguments.

Spectral instability for NLS equations on metric graphs

Nataliia Goloshchapova
Universidade de São Paulo

An orbital stability of a solitary wave to a Hamiltonian model

$$\frac{du}{dt} = JE'(u(t)) \tag{8}$$

means that a solution to the Cauchy problem stays close to an orbit generated by the wave profile when an initial data is close to the profile.

It is commonly believed that the orbital instability of a solitary wave solution follows from exponential growth of a solution to a corresponding linearization of model (8).

The existence of such exponentially growing solutions frequently is called *a spectral instability*. Practically it means that the linearization operator L has at least one eigenvalue with a positive real part. In particular, stability study mainly involves investigation of a spectrum of L.

We will discuss how to apply the Grillakis-Jones theory to establish the spectral instability for the standing wave solutions to nonlinear Schrödinger equations on star graphs. To do that we use the extension theory of symmetric operators and a generalization of the Sturm theory for star graphs. This theories are applied to a pair of self-adjoint operators associated with L.

Implementation of mitigation measures and modelling of in-hospital dynamics depending on the COVID-19 infection status

Pablo Castañeda, Mayra Núñez López, Rodrigo Zepeda Tello, Sarah Skolnick, Rafael Meza, Mauricio Hernández Ávila
Instituto Tecnológico Autónomo de México

In this lecture, we present a mathematical model that simulates several quarantine and isolation scenarios that allow the modeler to intervene in specific subgroups of the population by infection status. The quarantine and isolation processes rely on stepwise functions. In addition, the model accounts for a healthcare-system overload that could result in cascading catastrophic effects. With the purpose of studying the dynamics inside each healthcare unit, if there is time, we also present a stochastic extension of the model. In this extension, the patients are modeled from their entry until their discharge or death. The model predicts the total amount of individuals in hospital beds and the Intensive Care Unit (ICU) for each healthcare unit. Finally, we discuss how these models were used to inform decisions in the Mexican Institute of Social Security (IMSS) during the first months of the pandemic.

Disturbing the Big Bang

Phillipo Lappicy
Universidade Federal do Rio de Janeiro

We will give an introductory talk on the dynamics of the Big Bang singularity and perturbations thereof. This topic has attracted a great deal of attention of both mathematicians and physicists since the heuristic approach of Belinski–Khalatnikov–Lifshitz (known as BKL conjecture/picture) and the Mixmaster attractor construction of Misner. We will see how a specific perturbation of the Big Bang singularity will unravel well-known and brand new dynamical features. Moreover, we will see how such perturbations yield good (or bad) approximating schemes of the usual Einstein's general theory of relativity. These results were fruit of collaborations with K.E. Church (U Montreal), V.H. Daniel (Columbia U), J. Hell (FU Berlin), O. Hénot (McGill U), J.P. Lessard (McGill U), H. Sprink (FU Berlin) and C. Uggla (Karlstad U).

Exploring the impact of temperature on the efficacy of replacing the wild *Aedes aegypti* population by *Wolbachia*-carrying one

Sergio Oliva, Luís Lopes, Claudia P. Ferreira
Universidade de São Paulo

A non-autonomous delay differential model is proposed to reproduce the competitive dynamics of *Wolbachia*-infected and non-infected mosquito populations in several scenarios that differ by daily environment temperature, the bacterial strain that promotes the infection on mosquito, and the release guidelines of infected mosquitoes. Both mosquito entomological parameters and infection's traits depend on temperature, which *per si* depends on time. Therefore, inspired by the literature on ectotherms populations, functional forms are proposed to describe the rates of birth, development, and survival (or mortality) of *Ae. aegypti* as a function of temperature, as well as the rate of *Wolbachia*-infection loss. The simulations showed that multiple releases were more efficient than a single one, when the mosquito population is high is the best moment to implement the releasing of infected mosquitoes, strains that produce both high levels of cytoplasmic incompatibility and maternal inheritance boost the efficacy of the technique, high temperature can jeopardize the efficacy of the technique by both increasing the ratio of infected to non-infected mosquitoes necessary to achieve persistence of the infection, and diminishing the prevalence of the infection in the long run.

Dynamics of the Bresse-Timoshenko system

To Fu Ma
Universidade de Brasília

The Bresse system models thin circular beams and reduces to the well-established Timoshenko system when the curvature goes to zero. Here we discuss the main differences on the dynamics of these two models.

Computational Dynamics

Organizer: Marcio Gameiro (USP/Brazil) & Konstantin Mischaikow (Rutgers University/USA)

Identifying Nonlinear Dynamics with High Confidence from Sparse Data

Bogdan Batko, Marcio Gameiro, Ying Hung, William Kalies, Konstantin Mischaikow, and Ewerton Vieira
Jagiellonian University

We introduce a novel procedure that, given sparse data generated from a stationary deterministic nonlinear dynamical system, can characterize specific local and/or global dynamic behavior with rigorous probability guarantees. More precisely, the sparse data is used to construct a statistical surrogate model based on a Gaussian process (GP). The dynamics of the surrogate model is interrogated using combinatorial methods and characterized using algebraic topological invariants (Conley index). The GP predictive distribution provides a lower bound on the confidence that these topological invariants, and hence the characterized dynamics, apply to the unknown dynamical system (a sample path of the GP). The focus of this talk is on explaining the ideas, thus we restrict our examples to one-dimensional systems and show how to capture the existence of fixed points, periodic orbits, connecting orbits, bistability, and chaotic dynamics.

On the Interplay between Topology and Dynamics on Singular Surfaces

Dahisy Lima
Universidade Federal do ABC

In this talk, we address the advances in the study of Gutierrez-Sotomayor singular flow (GS flow, for short) on closed singular 2-manifolds. We make use of Conley Index Theory to describe the change in the topology of the level set of a singular surface as one passes through a GS singularity (cone, cross-cap, double crossing, and triple crossing singularities). Moreover, we explore the dynamical behaviour of GS-singularities within GS-flows through homotopical perturbations in order to achieve a "minimal flow" into the class of homotopy equivalent spaces. This is done by describing the qualitative aspects of the flow φ^{GS} in terms of a chain complex $(C_*(GS), \Delta^{GS})$ generated by the singularities of φ^{GS} and establishing a homotopical cancellation theory of GS-singularities.

Combinatorial description of global dynamics via piecewise linear models.

Ewerton Rocha Vieira
Rutgers University

For multi-scale systems, where the variables and parameters are typically numerous and poorly measured (for example biological systems), it is extremely difficult to perform a direct analysis to understand the global dynamics. To address this challenge, I will present coarser modeling tools based on combinatorics and algebraic topology. In this novel approach, we move away from the classical ODE analysis (trajectories and invariant sets) and focus toward robust, scalable and computable description of dynamics in terms of Morse graphs. More specifically, the method is based on piecewise linear models with formal mathematical guarantees that extend to a class of ODE with steep sigmoidal nonlinearities.

Sequential attractors in threshold-linear networks

Katherine Morrison
University of Northern Colorado

Sequences of neural activity arise in many brain areas, including cortex, hippocampus, and central pattern generator circuits that underlie rhythmic behaviors like locomotion. In this talk, we examine network architectures that give rise to sequential activity, via dynamic attractors, in a special family of threshold-linear networks known as *combinatorial threshold-linear networks* (CTLNs). Such networks enable us to isolate the role of connectivity in shaping dynamics, as they are simplified models whose dynamics are tightly connected to an underlying directed graph. To identify architectures that produce sequential attractors, we exploit the observation that these attractors appear to be closely related to particular unstable fixed points of the network. We then show how these fixed points can be determined via graph-based rules. These rules provide a direct link between the structure and function of these networks and give insight into network motifs that produce sequential attractors.

Entropic Transfer Operators

Oliver Junge, Daniel Matthes (TUM), Bernhard Schmitzer (U Goettingen)
Technical University of Munich

We propose a new concept for the regularization and discretization of transfer operators in dynamical systems. Our approach is based on the entropically regularized optimal transport between two probability measures. In particular, we use optimal transport plans in order to construct a finite-dimensional approximation of some transfer operator which can be analysed computationally. We prove that the spectrum of the discretized operator converges to the one of the regularized original operator, give a detailed analysis of the relation between the discretized and the original peripheral spectrum for a rotation map on the n-torus and provide code for three numerical experiments, including one based on the raw trajectory data of a small biomolecule from which its dominant conformations are recovered.

Computing equilibria and saddle-node bifurcations in overparameterized models of gene regulation

Shane Kepley
Vrije Universiteit Amsterdam

Hill Models are widely used for modeling gene regulatory network dynamics. However, they suffer from a rapid increase in the parameter dimension as additional gene interactions become involved. This presents a significant difficulty when studying equilibria in Hill models as their existence, location, and stability can vary wildly due to a variety of bifurcations In this talk we introduce techniques for finding saddle-node bifurcations globally in the parameter space despite the high dimension. Our approach combines topological and combinatorial techniques which initially reduce the subset of parameters on which to search with fast numerical algorithms for finding these bifurcations based on solving an appropriate zero finding problem. We will demonstrate the approach with several examples.

Dispersive Equations

Organizer: Marcia A. G. Scialom (UNICAMP/Brazil) & Mahendra Panthee (UNICAMP/Brazil)

On the Cauchy problem associated with a generalized Gross-Pitaevskii model

Adán J. Corcho, Hichem Hajaiej
Universidade Federal do Rio de Janeiro

We study a non-equilibrium Gross-Pitaevskii type system recently proposed to model exciton-polariton condensates. The coupled dispersive-dissipative equations present numerous mathematical challenges, and the known previous methods do not seem to apply in a standard way to study the global dynamics and singularity formation. We consider initial data in Sobolev spaces defined on euclidean and periodic domains andwe prove global in-time existence results for small data (in all dimensions) with regularity above the algebra structure under some extra hypotheses. By using Strichartz estimates, we obtain global wellposedness in the one-dimensional case in the space $L^2 \times L^2$ (with exponential decay in some physical cases), which can not be applied to higher dimensions. Furthermore, under some physical assumptions, we show the existence of initial data, in both cases (euclidean and periodic), such that the corresponding solutions blow-up in finite or infinite time (with exponential rate). We also present an interesting result about the existence of initial data with higher regularity, in periodic domains, such that the corresponding solutions either blow-up in finite time or have unboundedness Sobolev norms with vanishing dissipation parameter.

Stabilization for the dispersion generalized Benjamin equation

Ademir Pastor, Francisco Javier Vielma Leal
Universidade Estadual de Campinas

In will we discuss some recents results on the controllability and stabilization for the dispersion generalized Benjamin equation on a periodic domain. First, by assuming the control input acts on all the domain, it is proved the exact controllability in the usual Sobolev spaces of positive index. Second, by providing a locally-damped term added to the equation as a feedback law, it is shown that the resulting equation is globally well-posed and locally exponentially stabilizable in the space in L2.

Global control aspects for long waves in nonlinear dispersive media

Andressa Gomes, Roberto Capistrano-Filho
Universidade Federal do Delta do Parnaíba

In this talk we consider a class of models of long waves in dispersive media with coupled quadratic nonlinearities on a periodic domain $\mathbb{T}$. We use a new *bilinear estimate* on Bourgain spaces with two different dispersions to guarantee a global control result for coupled systems of the Korteweg–de Vries type. More precisely, we use spectral analysis to obtain that the system in consideration is locally controllable in $H^s(\mathbb{T})$, for $s \geq 0$. After that, by certain properties of Bourgain spaces we show a property of global exponential stability. This property together with the local exact controllability ensures for the first time in the literature that long waves in nonlinear dispersive media are globally exactly controllable in large time. This is a joint work with Prof. Roberto Capistrano-Filho (UFPE).

Long time asymptotics of large data in the Kadomtsev-Petviashvili models

Argenis Mendez
Pontificia Universidad Católica de Valparaiso

We consider the *Kadomtsev-Petviashvili* equations

$$\partial_t u + \partial_x^3 u + \kappa \partial_x^{-1} \partial_y^2 u + u \partial_x u = 0 \tag{9}$$

where $u = u(x, y, t)$ is a real valued function, and $\kappa \in \{-1, 1\}$. In the case $\kappa = -1$, the equation (9) is known as KP-I and for $\kappa = 1$ it is known as KP-II equation. For both equations, we provide sequential in time asymptotic descriptions of solutions, of arbitrarily large data, inside regions not containing lumps or line solitons, and under minimal regularity assumptions. The proof involves the introduction of two new virial identities adapted to the KP dynamics, showing decay in large regions of space, especially in the KP-I case, where no monotonicity property was previously known. Our results do not require the use of the integrability of KP and are adaptable to well-posed perturbations of KP.

This is a work in collaboration with C. Muñoz (CNRS and Departamento de Ingeniería Matemática and Centro de Modelamiento Matemático), F. Poblete (Universidad Austral de Chile), and J.C Pozo (Universidad de Chile).

Orbital stability of periodic traveling waves for the "abcd" Boussinesq systems

Gabriel Eduardo Bittencourt Moraes, Fabio Natali, Guilherme de Loreno
State University of Maringá

New results concerning the orbital stability of periodic traveling wave solutions for the "abcd" Boussinesq model

$$\begin{cases} \eta_t + u_x + (\eta u)_x + a u_{xxx} - b \eta_{xxt} = 0 \\ u_t + \eta_x + u u_x + c \eta_{xxx} - d u_{xxt} = 0, \end{cases}$$

where $\eta, u : \mathbb{R} \times (0, +\infty) \to \mathbb{R}$ are real-valued functions which are L-periodic at the spatial variable and $a, b, c, d \in \mathbb{R}$ are suitable real parameters will be shown in this talk. For the existence of solutions, we use basic tools of ordinary differential equations to show that the corresponding periodic wave depends on the Jacobi elliptic function of cnoidal type. The spectral analysis for the associated linearized operator is determined by using some tools concerning the Floquet theory. The orbital stability is then established by applying the abstract results [1] and [2] which give us sufficient conditions to the orbital stability for general class of evolution equations.

References:

[1] T. P. Andrade and A. Pastor. Orbital stability of one-parameter periodic traveling waves for dispersive equations and applications. *J. Math. Anal. Appl.*, 475 (2019), 1242-1275.

[2] M. Grillakis, J. Shatah, W. Strauss. Stability theory of solitary waves in the presence of symmetry I. *J. Funct. Anal.*, 74 (1987), 160-197.

Global well-posedness and blow-up results for semi-linear evolution equations with a time-dependent damping

Halit Sevki Aslan
Universidade de São Paulo

This work is concerned with studying the following semi-linear σ-evolution equations with time-dependent damping in the whole space:

$$\begin{cases} u_{tt}(t,x) + (-\Delta)^{\sigma} u(t,x) + b(t)u_t(t,x) = |u(t,x)|^p, & (t,x) \in [0,\infty) \times \mathbb{R}^n, \\ u(0,x) = \varepsilon u_0(x), \quad u_t(0,x) = \varepsilon u_1(x), & x \in \mathbb{R}^n, \end{cases} \tag{10}$$

where $\sigma > 1$ is assumed to be any fractional number and $p > 1$. In the present work, mainly we investigate the global well-posedness property of small data solutions and the large-time behavior of these obtained global solutions to the semi-linear problem in the so-called effective damping cases by using optimal decay estimates for solutions to the corresponding linear equation. Another novelty is that the application of a modified test function gives a blow-up phenomenon and lifespan estimates for solutions as well, where σ is not necessarily assumed to be an integer as in several previous papers, i.e. σ is any fractional number.

On the regularized Benjamin-Ono System on half space

Jose R. Quintero, Liliana Esquivel
Universidad del Valle

In this work, we consider the initial boundary value problem for the regularized Benjamin-Ono system on the half line

$$\begin{cases} v_t - u_x - \frac{\epsilon^2}{6} v_{xxt} = -\alpha (vu)_x, & x > 0,\ t > 0, \\ u_t - \left(\frac{\rho_2}{\rho_1} - 1\right) v_x - \frac{\rho_2}{\rho_1} \epsilon \mathcal{H}(u_{xt}) - \frac{\epsilon^2}{6} u_{xxt} = -\frac{\alpha}{2} (u^2)_x, & x > 0,\ t > 0, \\ u(0,x) = u_0(x), \quad v(0,x) = v_0(x), & x > 0, \\ u(t,0) = h_1(x), \quad v(t,0) = h_2(t), & t > 0. \end{cases} \tag{11}$$

This dispersive system describes the propagation of a weakly nonlinear internal wave propagating at the interface of two immiscible fluids with constant densities, which are contained at rest in a long channel with a horizontal rigid top with constant density ρ_1 and bottom with constant density ρ_2, and the thickness of the lower layer is assumed to be effectively infinite (deep water limit), where the constants ρ_1 and ρ_2 are such that $\rho_2/\rho_1 > 1$ holds (for stable stratification), constants ϵ and α are small positive numbers such that $\alpha = O(\epsilon^2)$ defined as $\epsilon = \hbar_1/L$ and $\alpha = a/\hbar_1$, that measure the intensity of the dispersive and nonlinear effects, respectively. Here $\hbar_1$ denotes the thickness of the upper fluid layer and the parameters L and a correspond to the characteristic wavelength and characteristic wave amplitude, respectively. The variable t denotes the propagation time and x represents the spatial position. The function $u = u(x,t)$ is the velocity monitored at the normalized depth $z = 1 - \sqrt{\frac{2}{3}}$, and $\zeta = \zeta(x,t)$ is the wave amplitude at the point x and time t, measured with respect to the rest level of the two-fluid interface.

We study the wellposedness for the initial-boundary value problem following a recent work by D. Cardona and L. Esquivel in [1] (see also works by N. Hayashi and E. Kaikina in [2], [3]). We take xt-Laplace transform to characterize solutions for the linear problem, using Sokhotski–Plemelj formula and the zero index Lemma.

References:

[1] D. Cardona, L. Esquivel. On the Benjamin–Ono equation in the half line. *Nonlinear Analysis*, 212 (2021), 112427.

[2] N. Hayashi, E. I. Kaikina. Benjamin-Ono equation on a half-line. *International Journal of Mathematics and Mathematical Sciences*. Volume 2010, Article ID 714534, 38 pages.

[3] N. Hayashi, E. I. Kaikina. Neumann initial-boundary value problem for Benjamin-Ono equation. *Journal of Differential Equations*, 252(5) (2012), 3520-3540.

On the intercritical inhomogeneous NLS equation

Luiz Gustavo Farah
Universidade Federal de Minas Gerais

We consider the inhomogeneous nonlinear Schrödinger (INLS) equation

$$iu_t + \Delta u + |x|^{-b}|u|^{2\sigma}u = 0, \;\; x \in \mathbb{R}^N,$$

with $N \geq 1$ and $0 < b < \min\{\frac{N}{2}, 2\}$. The above model is a generalization of the classical nonlinear Schrödinger equation (NLS), obtained when $b = 0$. We focus on the intercritical case, where the scaling invariant Sobolev index $s_c = \frac{N}{2} - \frac{2-b}{2\sigma}$ satisfies $s_c \in (0, 1)$.

In this talk we discuss well-posedness, scattering and blow-up results for the INLS equation in the radial and non-radial settings. These results were obtained in collaboration with Mykael Cardoso (UFPI-Brazil), Carlos Guzmán (UFF-Brazil), Luccas Campos (UFMG-Brazil), Jason Murphy (Missouri S&T-USA) and Simão Correia (IST-Portugal).

This work is partially supported by CNPq, CAPES and FAPEMIG-Brazil.

The effect of higher-order dissipation on solutions of the generalized Korteweg-de Vries equation

Mahendra Panthee, J. Bona, H. Chen, Y. Hong, M. Scialom
Universidade Estadual de Campinas

In this talk we consider the generalized Korteweg-de Vries equation

$$\partial_t u + \partial_x u + u^p \partial_x u + \partial_{x^3} u \; = \; 0$$

in the supercritical case $p \geq 4$. For such values of p, it is expected that large initial data can lead to smooth solutions that blow up in finite time.

The question raised here is whether or not addition of a suitable dissipative term could mitigate this putative blowup. The dissipative addition considered here is of the form $(-1)^m \nu \partial_x^{2m} u$ where $\nu > 0$. It will turn out that for $m \geq 2$, there are values of $p > 4$ for which global well posedness obtains for arbitrarily-valued initial data and any $\nu > 0$. In general, it is shown that for any value of p and initial data u_0 of a given norm, there is a ν_0 depending on that norm such that if $\nu > \nu_0$, then the solution emanating from u_0 is global. However, if $p > 4m - 2$, numerical simulations show that solutions can still blow up even in the presence of dissipation if ν is not large enough.

Local and Global Theory for the Three-Wave mixing Schrödinger system with quadratic interactions on Zoll manifolds

Marcelo Aparecido Cabral Nogueira, Mahendra Prasad Panthee
Universidade Federal de Itajubá

Well-posedness issues for the initial value problem (IVP) associated to the three-wave mixing Schrödinger system with quadratic nonlinearities posed on d-dimensional Zoll manifold M with initial data in $\mathbf{H}^s(M)$ are investigated. New bilinear Strichartz's type estimates for the interacting evolution groups are obtained considering that the system parameter η be a rational number. As a consequence, bilinear estimates for the interacting nonlinearities are obtained so as to prove the local well-posedness results with initial data in $\mathbf{H}^s(M)$ whenever $s > \frac{1}{4}$ if $d = 2$ and $s > \frac{d-2}{2}$ if $d \geq 3$. Using some conserved quantities combined with the sharp Gagliardo-Nirenberg inequality the global well-posedness results are also obtained in dimensions $d = 2, 3$ for initial data with Sobolev regularity $s \geq 1$. The present work improves the earlier results for the 2×2 Schrödinger system in [?] relaxing the restrictions on the system parameter and consequently the local and global well-posedness results there. This is a joint work with M. Panthee from University of Campinas (UNICAMP)

Lower bounds on the radius of analyticity for some KdV type equations.

Renata O. Figueira, Mahendra Panthee, Alex Himonas, Rafael Barostichi
University of Campinas

We shall consider the Cauchy problem on the line for three equations: the Benjamin equation, the modified KdV and NLS equations with high dispersion, where the initial data belongs in a class of analytic functions on the line that can be extended holomorphically in a symmetric strip around x-axis. From the result about local well-posedness in these classes of functions, we guarantee the analytic regularity of the solutions in space variable without shrinking the width of the strip for short times.

This talk is devoted to discuss the evolution in time of the radius of spatial analyticity and show that it can decreases as the time advances. Also, we present an algebraic lower bound on the possible rate of decrease in time of the uniform radius of spatial analyticity for each one of the equations.

These works are in collaboration with Mahendra Panthee, Rafael Barostichi and Alex Himonas.

Nonlinear schrödinger equations with the third order dispersion onmodulation spaces

Xavier Carvajal, Mahendra Panthee
Universidade Federal Do Rio De Janeiro

We consider the initial value problems (IVPs) associated to the extended nonlinear Schrödinger (e-NLS) equation

$$\partial_t v + i\alpha\partial_x^2 v - \partial_x^3 v + i\beta|v|^2 v = 0, \quad x, t \in \boldsymbol{R},$$

and the higher order nonlinear Schrödinger (h-NLS) equation

$$\partial_t u - i\alpha\partial_x^2 u + \partial_x^3 u - i\beta|u|^2 u + \gamma|u|^2\partial_x u + \delta\partial_x(|u|^2)u = 0, \quad x, t \in \boldsymbol{R},$$

for given data in the modulation space $M_s^{2,p}(\boldsymbol{R})$. We derive a trilinear estimate for functions with negative Sobolev regularity and use it in the contraction mapping principle to prove that the IVPs associated to the e-NLS equation and the h-NLS equation are locally well-posed for $s > -\frac{1}{4}$ and $s \geq \frac{1}{4}$ respectively.

Domain Perturbations, PDEs and Dynamics

Organizer: José M. Arrieta (UCM/Spain) & Marcone C. Pereira (USP/Brazil)

Spectral analysis on ruled surfaces

Alessandra A. Verri, Rafael T. Amorim
Universidade Federal de São Carlos

Let Ω be an unbounded two dimensional strip on a ruled surface in $\mathbb{R}^d$, $d \geq 2$. Consider the Laplacian operator in Ω with Dirichlet and Neumann boundary conditions on opposite sides of Ω. We prove some results on the existence and absence of the discrete spectrum of the operator; which are influenced by the twisted and bent effects of Ω. The interest in those considerations lies on the difference from the purely Dirichlet case.

Continuity of attractors for a oscilatory perturbation of the square

Antonio Luiz Pereira , Bianca Paolini Lorenzi
Universidade de São Paulo

We prove continuity of attractors for a family of perturbations o the square in $\mathbb{R}^2$, which do not converge in the C^1 norm.

Nonlinear coupled system in thin domains with corrugated boundaries for metabolic processes

Jean Carlos Nakasato, Giuseppe Cardone, Luisa Faella, Carmen Perugia
Universidade de São Paulo

In this paper, we study the asymptotic behaviour of solutions of a coupled system of partial differential equations in a thin domain with oscillating boundary and varying order of thickness.

In such a thin domain, our model describes the solute concentration of two different biochemical species (metabolites). The coupling between the concentrations of the metabolites is realized through reaction terms even nonlinear, appearing either in the thin domain or on the oscillating upper wall. The reaction catalyzed by the upper wall is simulated by a Robin-type boundary condition depending on a small parameter ε. Hence, taking into account that $\alpha > 1$ and $\beta > 0$, we analyze the coupled system by comparing the magnitude of the reaction coefficient ε^β on the upper boundary with the compression order of our thin domain, which can be ε or ε^α, depending on the sub-regions with different order of thickness. Comparing the exponents 1, α and β, we obtain different cases for the limit problem which could appear coupled or uncoupled and allow us to identify the effects of the geometry and the physical process on the problem. Moreover it arises a critical value, i.e. $\beta = \alpha - 2$, leading the reaction effects entering in the diffusion matrix.

Thin domains with doubly oscillatory boundary: the weak-resonant case

Joaquín Domínguez de Tena
ICMAT-Universidad Complutense de Madrid

Thin domains are those for which the size in some direction is significantly smaller than in others. They appear in many areas of science: fluid dynamics (lubrication, conduction in tubes), solid dynamics (thin rods, plates), or even physiology (blood circulation). In our work, we consider the following thin domain

$$R_\varepsilon = \{(x,y) \in \mathbb{R}^2 \ : \ x \in (0,1), \ -\varepsilon g(\frac{x}{\varepsilon^\alpha}) < y < \varepsilon h(\frac{x}{\varepsilon^\beta})\}.$$

where g and h are periodic functions, $\alpha = 1$ and $\beta < 1$. We study the solutions of the following PDEs

$$\Delta u^\varepsilon(x) + u^\varepsilon(x) = f(x) \qquad x \in R_\varepsilon$$

with zero Neumann boundary conditions and let $\varepsilon \to 0$. This is the case of doubly periodic homogenization in thin domains in which we have resonant homogenization ($\alpha = 1$, so the order of oscillations' period is the same as of the thickness of the domain) and weak homogenization ($\beta < 1$ so the thickness is significantly smaller). The cases of weak-weak and strong-any homogenization had already been solved with different techniques. We will present the principal ideas to solve the weak-resonant case with the techniques of the unfolding operator and reiterated homogenization. This is a joint work with José María Arrieta (UCM-ICMAT) and Manuel Villanueva-Pesqueira (UPCO).

Domain deformations and eigenvalues of degenerate differential self-adjoint operator

Marcus Marrocos
Universidade Federal do Amazonas

We consider the spectral problem for a class of degenerate self-adjoint differential operators subject to homogeneous Dirichlet boundary conditions on a bounded open subset of $\mathbb{R}^n$. We prove an Hadamard-type formula for their shape differential and describe the bifurcation phenomenon of multiple eigenvalues. We also discuss other homogeneous boundary conditions.

A nonlinear boundary homogenization problem with high contrasts on the boundary conditions.

Maria Eugenia Pérez-Martínez
Universidad de Cantabria

We consider a homogenization problem for the Laplace operator posed in a bounded domain of the upper halfspace, a part of its boundary being in contact with the plane. On this part, the boundary conditions alternate from Neumann to nonlinear-Robin, being of Dirichlet type outside. The nonlinear-Robin boundary conditions are imposed on small regions periodically placed along the plane and contain a Robin parameter that can be very large. Depending on the different relations between parameters (period, size of the regions and Robin parameter), a nonlinear capacity term may arise in the strange term which depends on the macroscopic variable and allows us to extend the usual capacity definition to semilinear boundary conditions, cf. [1]. Some possible extensions to the elasticity system are considered.

References:

[1] Gómez, D., Pérez-Martínez, M.-E. Boundary homogenization with large reaction terms on a strainer-type wall. Z. Angew. Math. Phys. 73, 234 (2022).
https://doi.org/10.1007/s00033-022-01869-8

On the MHD flow through a perturbed channel filled with a porous medium

Marko Radulovic, Igor Pazanin, Eduard Marusic-Paloka
University of Zagreb

This is a joint work with I. Pažanin and E. Marušic-Paloka.

In this talk, we will investigate the effects of a slightly perturbed boundary on the MHD flow through a channel filled with a porous medium. We start from a rectangular domain and then perturb the upper part of its boundary by the product of the small parameter ϵ and an arbitrary smooth function h.

Employing asymptotic analysis with respect to ϵ, we derive the first-order effective model. We can clearly observe the nonlocal effects of the small boundary perturbation with respect to the Hartmann number since the asymptotic approximation is derived in explicit form. Theoretical error analysis is also provided, rigorously justifying our formally derived model.

Band-gap stucture in a film-like waveguide

Rafael Orive-Illera
ICMAT-Universidad Autónoma de Madrid

In this talk, we show the band-gap structure of the spectrum of the Dirichlet and Neumann problem for the Laplace operator in a strip with periodic dense transversal perforation by identical holes of a small diameter $\varepsilon > 0$.

This is motivated by different works in collaboration of Delfina Gómez, Sergey Nazarov and María Eugenia Pérez-Martínez.

Nonlocal diffusion and perforated domains

Silvia Sastre Gómez, Silvia Sastre Gómez, Marcone C. Pereira, Aníbal Rodríguez-Bernal
Universidad de Sevilla

In this work, we analyze the behavior of the solutions to nonlocal evolution equations with a nonlocal nonlinear reaction term in a perturbed perforated domain. This perforated domain is thought of as a fixed set from where we remove a subset called the holes. We choose appropriated families of bounded functions in order to deal with both Neumann and Dirichlet conditions in the holes setting and Dirichlet conditions outside the domain. Under the assumption that the characteristic functions of the perturbed domain have a weak limit, we study the limit of the solutions providing a nonlocal homogenized equation. This is joint work with and Marcone C. Pereira.

Dynamical Systems and Ergodic Theory

Organizer: Maria José Pacífico (UFRJ/Brazil), Ali Tahzibi (USP/Brazil) & Daniel Smania (USP/Brazil)

Equilibrium states for maps isotopic to Anosov

Adriana Sánchez Chavarría, Carlos Fabián Álvarez, Regis Varão
Universidad de Costa Rica

Given a diffeomorphism f over a compact manifold M, an *equilibrium state* for a continuous *potential* $\phi : M \to \mathbb{R}$, is an f-invariant Borel probability measure μ that maximizes the quantity

$$h_\mu(f) + \int \phi d\mu,$$

where $h_\mu(f)$ represents the metric entropy of f.

In this talk we will address the problem of existence and uniqueness (finiteness) of ergodic equilibrium states for partially hyperbolic diffeomorphisms isotopic to Anosov on T^4, with 2-dimensional center foliation. This is done by studying the disintegration of measures along 1-dimensional subfoliations of the center bundle.

This is a joint work with C. Álvarez and R. Varão.

Three dimensiónal star flows are multisingular hiperbolic

Adriana Victoria da Luz Angeloni
Universidade Federal Fluminense

The coexistence of singularities and regular orbits in chain transitive sets has been a major obstacle in understanding the hyperbolic/partial hyperbolic nature of robust dynamics. Notably, the vector fields with all periodic orbits robustly hyperbolic (star flows), are hyperbolic in absence of singularities but are not in general. For a long time much effort was devoted to understand if they can be characterized by some weaker hyperbolic structure. Bonatti and da Luz characterize an open and dense set of star vector fields by multi-singular hyperbolicity. In this talk we will discuss a work in collaboration with Bohorquez and Tamblay. We prove that all three-dimensional star flows are multi-singular hyperbolic. Additionally, star flows with robust chain recurrence classes in any dimension are multi-singular hyperbolic. We will also discuss some work in progress to address the same question in higher dimensions.

Asymptotic analysis of interacting urns with reinforcement on graphs

Benito Pires, Rafael A. Rosales
Universidade de São Paulo

Many processes in the real-world (e.g. Google's search engine) consists in making choices with probabilities in proportion to the total reward accumulated when making that choices in the past.

A universal mathematical model for such processes are the interacting urns with reinforcement on graphs. We will discuss a multiple colour generalisation of the model of graph interacting urns studied by Benaim et. al., Random Struct. Alg., 46: 614-634, 2015. We show that for complete graphs and for a broad class of reinforcement functions governing the addition of balls in the urns, the process of colour proportions at each urn converges almost surely to the fixed points of the reinforcement function. Joint work with Rafael A. Rosales.

A dynamical Thouless formula

Catalina Freijo, Jamerson Bezerra, Ao Cai, Pedro Duarte, Silvius Klein
Universidade de São Paulo

In this talk we establish an abstract, dynamical Thouless-type formula for affine families of GL(2,R) cocycles. This result extends the classical formula relating, via the Hilbert transform, the maximal Lyapunov exponent and the integrated density of states of a Schrodinger operator. Here, the role of the integrated density of states will be played by a more geometrical quantity, the fibered rotation number. As an application of this formula we present limitations on the modulus of continuity of random linear cocycles. Moreover, we derive Holder-type continuity properties of the fibered rotation number for linear cocycles over various base dynamics.

Robust transitivity and domination for endomorphisms displaying critical points

Cristina Lizana, Rafael Potrie, Enrique Pujals, Wagner Ranter
Universidade Federal da Bahia

We show that robustly transitive endomorphisms of a closed manifolds must have a non-trivial dominated splitting or be a local diffeomorphism. This allows us to get some topological obstructions for the existence of robustly transitive endomorphisms. To obtain the result we must understand the structure of the kernel of the differential and the recurrence to the critical set of the endomorphism after perturbation. This is a joint work with R. Potrie, E. Pujals and W. Ranter.

Partial hyperbolicity with topological neutral center

Gabriel Ponce
Universidade Estadual de Campinas

The theory of partially hyperbolic maps has been extensively studied in several directions including, for example, the study of ergodic properties under suitable center conditions. Recent new examples of partially hyperbolic dynamics, brought to attention a class of partially hyperbolic maps $f : M \to M$ where the central direction, say E^c, has a very "controlled" behavior in the sense that given any $\varepsilon > 0$, there exists $\delta > 0$ for which given any C^1 arc γ tangent to the center direction E^c, we have:

$$\text{length}(\gamma) < \delta \Rightarrow \text{length}(f^n(\gamma)) < \varepsilon,$$

for any $n \in \mathbb{Z}$. This class is called the class of partially hyperbolic maps with topological neutral center. In this talk we will present several metric and ergodic properties recently obtained for this class assuming the center direction is one-dimensional. These properties include a dichotomy between atomicity of the center direction and the Bernoulli property, and a type of invariance principle for ergodic invariant measures.

Contracting on average for random dynamical systems

Graccyela Salcedo, Katrin Gelfert
Universidade de São Paulo

We study contracting on average for Random Dynamical Systems (RDS) on compact metric spaces. We establish sufficient and necessary conditions to guarantee the existence of a metric for which a RDS is contractive on average. I will present some interesting examples of RDS on the circle for which the results apply.

Absolutely continuous invariant measures for partially hyperbolic endomorphisms satisfying a transversality condition

Ricardo Bortolotti
Universidade Federal de Pernambuco

We study physical measures for partially hyperbolic attractors for local diffeomorphisms whose central direction is neutral and satisfy a geometric transversality condition between the unstable directions. We prove existence and finiteness of physical measures, we also prove that these measures are absolutely continuous and the union of their basins has total volume in the basin of attraction of the attractor.

Furthermore, we verify that if the attractor has neutral central direction and that the action of the derivative on the unstable direction is close to conformal, then it is possible to perturb the dynamics in a way to satisfy the geometric condition of transversality and, therefore, has finite absolutely continuous physical measures.

Fluid Dynamics

Organizer: Anne Bronzi (UNICAMP/Brazil) & Gabriela Planas (UNICAMP/Brazil)

On the self-similar blowup for the generalized SQG equations

Anne Bronzi, Cecília Mondaini (Drexel Univ., EUA), Ricardo Guimarães (Unicamp)
Universidade Estadual de Campinas

In this talk, we will discuss the locally self-similar blow-up scenario for the generalized 2D SQG equations. We will show that the self-similar blow-up can be excluded in a supercritical range under some mild control on the L^p growth of the self-similar profile.

The Inverse Wiegner's Theorem for the Navier-Stokes Equations and Some Consequences

Cilon Perusato, Lorenzo Brandolese, Paulo Zingano
Universidade Federal de Pernambuco

In 1987, Michael Wiegner provided a fundamental result concerning the decay of solutions to the Navier-Stokes equations from the decay of the Stokes flows. Recently, Z. Skalak showed the converse of this theorem. In this work, we give an alternative proof of this result which can be generalized to other contexts. Related results are also discussed.

Asymmetric vortex patch for the gSQG

Edison Fausto Cuba Huamani, Lucas C. F. Ferreira
Universidade Estadual de Campinas

This talk aims to study the existence of steady asymmetric solutions for the two-dimensional generalized quasi-geostrophic (gSQG) model of simply connected patches for $\alpha \in [1, 2)$ in the plane. More precisely, we construct non-trivial time periodic simply connected co-rotating and traveling patches with unequal vorticity amplitude. The proof is carried out by means of a combination of a desingularization argument with the implicit function theorem on the linearization of contour dynamics equation.

Decay for 3D Navier-Stokes and Navier-Stokes-Coriolis equations in critical spaces

Gabriela Planas, Leonardo Kosloff, César Niche
Universidade Estadual de Campinas

In this talk, I will present an upper bound for the decay rate of solutions to the Navier-Stokes and Navier-Stokes-Coriolis equations in the Sobolev critical spaces. The main tool is the Fourier Splitting Method, which provides estimates in terms of the decay character of initial data.

Necessary and sufficient conditions for energy balance in 2D incompressible ideal fluid flow

Helena J. Nussenzveig Lopes, Fabian Jin (ETH-Zurich), Samuel Lanthaler (CalTech), Milton da Costa Lopes Filho (UFRJ), Siddhartha Mishra (ETH-Zurich)
Universidade Feral do Rio de Janeiro

We establish necessary and sufficient conditions on the regularity of the external force for energy balance to hold for solutions of the 2D incompressible Euler equations. This is motivated by turbulence modeling and in contrast with the situation in 3D and the existence of wild solutions.

This is a follow-up work on previous results by two of the authors.

Existence of weak solutions for nonhomogeneous cell-fluid Navier-Stokes model with inclusion of chemotaxis

Juliana Honda Lopes, Gabriela Planas
Universidade Federal do Rio de Janeiro

This work concerns with the mathematical study of the general cell-fluid Navier-Stokes model with inclusion of chemotaxis proposed in [2] in a particular case. This model is a general cell-fluid model that consists of two mass balance equations, two momentum balance equations for the cell and fluid phase and a convection-diffusion-reaction equation for the oxygen. The authors include the chemotaxis stress term in the pressure difference. This general model can represent the Chemotaxis-Navier-Stokes model in a special case. The purpose of this work is to investigate a particular case of the model proposed by the authors in [2] from a mathematical point of view. We consider the non-homogeneous case when the fluids have divergence free velocity vectors and constant volume fraction in a bounded domain $\Omega \subset \mathbb{R}^n$, $n = 2, 3$. To state the existence of weak solutions we apply the Semi-Galerkin method and we follow the idea of [1], for example.

References:

[1] S. A. Antontsev, A. V. Kazhikov, V. N. Monakhov. Boundary Value Problems in Mechanics of Nonhomogeneous Fluids, North Holland: Amsterdam, 1990.

[2] Y. Qiao and S. Evje. A general cell-fluid Navier-Stokes model with inclusion of chemotaxis, *Math. Models Methods Appl. Sci.*, 30 (6) (2020) 1167-1215.

A rescaled approach for the 3D-Boussinesq system in critical Fourier-Besov spaces

Leithold L. Aurazo-Alvarez
Universidade de Campinas

It is proved a global well-posedness result for a tridimensional rescaled Boussinesq system, with positive full viscosity and diffusivity parameters, in the framework of critical Fourier-Besov spaces, which allow homogeneous functions with negative degree. The rescaled approach implies to rescale both the velocity, dividing by a positive parameter, and the temperature, dividing by the square of the same parameter, and study the obtained system. This rescaled approach permits to deal with the right hand linear term for the Boussinesq system, in order to apply a fixed point lemma, and to know a qualitative behaviour of the system, according to relations between both the parameters and the initial velocity and temperature; for instance, it is possible to consider, for small enough viscosity and large diffusivity, a large enough critical Fourier-Besov norm for the initial temperature and it is also possible to consider, for small enough diffusivity and large viscosity, a large enough critical Fourier-Besov norm for both the velocity and the temperature.

The author was supported by CNPq (Brazil) and by University of Campinas, SP, Brazil.

Bounds of the radius of analyticity of solutions to the Navier-Stokes system

Milton C. Lopes Filho, David Ambrose, Helena J. Nussenzveig Lopes
Universidade Federal do Rio de Janeiro

In 2011, Z. Lei and F. Lin gave a proof of existence of a global mild solution of the three-dimensional Navier-Stokes equations in scale-invariant function spaces based on the Wiener algebra. An alternative proof of existence of these solutions was developed by H. Bae in 2017, and this new proof allowed for an estimate of the radius of analyticity of the solutions at positive times. We adapt the Bae proof to prove existence of the Lei-Lin solution in the spatially periodic setting, finding an improved bound for the radius of analyticity in this case.

The rigid body motion in Cosserat's fluid with Navier's slip boundary conditions

Nikolai V. Chemetov
Universidade de São Paulo

In the talk a brief presentation of recent results related to the body-fluid interaction problem will be given. The motion is described by a system of coupled differential equations: Newton's second law and Navier-Stokes type equations.

We shall formulate the global solvability result of weak solution of the problem, when the slippage is allowed at the boundaries of the rigid body and of the bounded domain, occupied by the fluid.

Harmonic Analysis and Related Topics

Organizer: Lucas Oliveira (UFGRS/Brazil) & Tiago Picon (USP/Brazil)

Extensions of Sobolev's theorem

Carlos Perez, Kabe Moen, Cong Hoang
University of the Basque Country and BCAM

We will discuss some extensions of classical Sobolev type inequalities for linear and non-linear operators. The key point is to show that many operators satisfy a pointwise bound by the Riesz potential applied to the gradient.

Magic Functions

Felipe Gonçalves, Promit Ghosal (MIT)
Instituto de Matemática Pura e Aplicada

We will talk about some challenging problems in different areas of mathematics that were solved by constructing certain "magic" functions with constraints on physical and/or frequency space. The talk will be entirely based on examples, one of which is the sphere packing problem and kissing numbers.

Scattering theory and nonlinear PDEs in interacting particle systems

Guilherme Silva
Universidade de São Paulo

The scattering theory for differential equations is the analogue of the Fourier transform tailored for the analysis of nonlinear partial differential equations displaying particular (integrable) structures. But it turns out that the same scattering theory also appears in the theory of particle systems which, among others, gives a playing field for the emergence of new families of integrable equations. We will survey some recent developments in this direction, showing how such nonlinear Fourier transform connects a celebrated stochastic equation, namely the KPZ equation, to a nonlocal equation arising from symmetries of the KdV equation.

This talk is partly based on joint work with Promit Ghosal (MIT).

Spectrum of differential operators with elliptic adjoint on a scale of localized Sobolev spaces

Luís Márcio Salge, Éder Ritis Aragão Costa (ICMC/USP)
Instituto Federal de Educação, Ciência e Tecnologia de Minas Gerais

In this work we provide a complete study of the spectrum of a constant coefficients differential operator on a scale of localized Sobolev spaces, $H^s_{loc}(I)$, which are Fréchet spaces. This is quite different from what we find in the literature, where all the relevant results are concerned with spectrum on Banach spaces.

Our aim is to understand the behavior of all the three types of spectrum (point, residual and continuous) and the relation between them and those of the dual operator. The main result we

present shows that there is no complex number in the resolvent set of such operators, which suggest a new way to define spectrum if we want to reproduce the classical theorems of the Spectral Theory in Fréchet spaces.

About uncertainty principles

Lucas Oliveira, João Pedro Ramos, Alexei Kulikov
Universidade Federal do Rio Grande do Sul

In this talk we will give a brief overview of various kinds of uncertainty principles in Harmonic Analysis and try to explain some contributions to the topic that we have obtained recently.

The talk is partially based on collaborative works with João Pedro Ramos, Alexei Kulikov

Fourier transform decay of distributions in Hardy-Morrey spaces

Marcelo F. de Almeida, Tiago H. Picon
Universidade Federal de Sergipe

In this note we establish decay estimates for Fourier transform on Hardy-Morrey spaces, namely,

$$|\widehat{f}(\xi)| \lesssim |\xi|^{n\left(\frac{1}{\lambda}-1\right)}\|f\|_{\mathcal{HM}^{\lambda}_{q}} \quad 0<p\leq\lambda\leq 1$$

and its localizable version. Our work include some aspects to these spaces linked up with previous estimates, in particular a natural approach on cancellation moment conditions. As application, we discuss the optimality for continuity of Fourier multipliers and pseudodifferential operators in Hardy-Morrey spaces.

Recent developments in Fourier interpolation

Mateus Sousa
Basque Center for Applied Mathematics (BCAM)

In this talk we will discuss some problems related to the theory of Fourier interpolation. The goal is to talk about the general problem of how to obtain new interpolation formulas from a previously known one, and to this end we will talk about perturbation arguments and also the task of how to obtain formulas without derivatives from formulas with derivatives.

The Dirichlet problem for unbounded domains in metric measure spaces

Ryan Gibara, Riikka Korte, Nageswari Shanmugalingam
University of Cincinnati

Let Ω be an unbounded locally compact metric measure space that is uniform in its completion. Assume that Ω is equipped with a doubling measure satisfying a p-Poincaré inequality and that the boundary of Ω is bounded. In joint work with Riikka Korte and Nageswari Shanmugalingam, we solve the p-Dirichlet problem for boundary data in an appropriate Besov class. This is accomplished by a conformal transformation of Ω, affecting both the metric and the measure, using a weight that depends on the distance to the boundary. The transformation renders Ω bounded while preserving many of its metric/measure properties without distorting the boundary.

Lebesgue solvability of elliptic homogeneous linear equations with measure data

Victor S. Biliatto, Tiago H. Picon
Universidade Federal de São Carlos

In this talk we present new results on solvability of the equation $A^*(D)f = \mu$ for $f \in L^p(\mathbb{R}^n)$ and positive measure data μ associated to an elliptic homogeneous differential operator $A(D)$ of order m. Our method is based on controlling the $(m,p)-$energy of μ giving a natural characterization for solutions when $1 \leq p < \infty$. We also obtain sufficient conditions in the limiting case $p = \infty$ using new L^1 estimates on measures for elliptic and canceling operators.

This is a joint work with Tiago Picon (FFCLRP-USP).

The Neumann problem on a torus

Zeinab Ashtab, Joao Morais, R. Michael Porter
Cinvestav-Centro de Investigación y de Estudios Avanzados

We consider the Dirichlet-to-Neumann mapping and the Neumann problem for the Laplace operator on a torus, given in toroidal coordinates. The Dirichlet-to-Neumann mapping is expressed with respect to series expansions in toroidal harmonics and thereby reduced to algebraic manipulations on the coefficients. A method for computing the numerical solutions of the corresponding Neumann problem is presented, and numerical illustrations are provided. We combine the results for interior and exterior domains to solve the Neumann problem for a toroidal shell.

Nonlinear Boundary Value Problems

Organizer: Raúl Manásevich (Uchile/Chile) & Gabrielle Nornberg (Uchile/Chile)

Uniform a priori estimates for positive solutions of the Lane-Emden system in the plane

Boyan Sirakov, Nikola Kamburov
PUC-Rio - Pontifícia Universidade Católica do Rio de Janeiro

We prove that positive solutions of the superlinear Lane-Emden system in a two-dimensional smooth bounded domain are bounded independently of the exponents in the system, provided the exponents are comparable. As a consequence, the energy of the solutions is uniformly bounded, a crucial information in their asymptotic study. In addition, the boundedness may fail if the exponents are not comparable.

Resonant solutions for elliptic systems with homogeneous Neumann boundary conditions

Briceyda B. Delgado, Rosa Pardo
Universidad Autónoma de Aguascalientes

We consider a sublinear perturbation of an elliptic eigenvalue system with homogeneous Neumann boundary conditions. Under suitable conditions for oscillatory nonlinearities and using bifurcation from infinity, we prove the existence of an unbounded sequence of turning points and of an unbounded sequence of resonant solutions.

Classification of radial blow-up at the first critical exponent for the Lin-Ni-Takagi problem in the ball

Denis Bonheure, Jean-Baptiste Castéras, Bruno Premoselli
Université Libre de Bruxelles

We investigate the behaviour of radial solutions to the Lin-Ni-Takagi problem in the ball $B_R \subset \boldsymbol{R}^N$ for $N \geq 3$:

$$\begin{cases} -\triangle u_p + u_p = |u_p|^{p-2}u_p & \text{in } B_R, \\ \partial_\nu u_p = 0 & \text{on } \partial B_R, \end{cases}$$

when p is close to the first critical Sobolev exponent $2^* = \frac{2N}{N-2}$. We obtain a complete classification of finite energy radial smooth blowing up solutions to this problem. We describe the conditions preventing blow-up as $p \to 2^*$, we give the necessary conditions in order for blow-up to occur and we establish their sharpness by constructing examples of blowing up sequences. Our approach allows for asymptotically supercritical values of p. We show in particular that, if $p \geq 2^*$, finite-energy radial solutions are precompact in $C^2(\overline{B_R})$ provided that $N \geq 7$.

Sufficient conditions are also given in smaller dimensions if $p = 2^*$.

Finally we compare and interpret our results to the bifurcation analysis of Bonheure, Grumiau and Troestler in Nonlinear Anal. 147 (2016).

Flipping regularity via Harnack approach and applications to nonlinear elliptic problems

Diego Moreira
Universidade Federal do Ceará

In this talk, I will present recent advances in the regularity theory of nonlinear elliptic problems. The results are related to a class of functions that satisfy abstract conditions associated with the Weak Harnack Inequality and $L^{\varepsilon} - L^{\infty}$ estimates. These features allow one-sided control to become complete control with estimates. These results can be applied to a wide spectrum of circumstances ranging from supersolutions to fully nonlinear elliptic to Q-minimizers of Giaquinta and Giusti in the Calculus of Variations. In particular, this gives new insights and encompasses recent results extending the sharp version of the Caffarelli-Kohn-Nirenberg-Spuck apriori estimates obtained in collaborations with Alessio Figalli (ETH-Zurich) and Ederson Braga (UFC). This is a work in Collaboration with Edgard Pimentel (University of Coimbra).

On a Hamiltonian system in dimension two with exponential nonlinearity

Elisandra Gloss, Bruno Ribeiro, Maria do Desterro Azevedo
Universidade Federal da Paraíba

In this talk, we explore the Hamiltonian system

$$\begin{cases} -\Delta u = g(v) & \text{in } \Omega, \\ -\Delta v = f(u) & \text{in } \Omega, \\ u = v = 0 & \text{on } \partial\Omega, \end{cases} \tag{12}$$

where $\Omega \subset \mathbb{R}^2$ is a bounded domain with smooth boundary $\partial\Omega$, and one of the nonlinearities, e.g. g, has exponential asymptotic growth.

We use the method of reduction by inversion, which consists of transforming the system (12) into a fourth-order equation, and than we apply variational methods, transforming the search for solutions to finding critical points of a functional defined in a suitable Orlicz-Sobolev reducted space, which is not reflexive.

On the Dirichlet problem for fractional equations that degenerate with the gradient

Erwin Topp, Disson dos Prazeres, Damião Araujo
Universidad De Santiago de Chile

In this talk, I will report some existence, uniqueness and multiplicity results for Dirichlet problems associated to degenerate elliptic fractional equations. The leading term in the equation is an integro-differential operator that degenerates with the gradient, a non-variational nonlocal analog to second-order operators like the p-Laplacian. In particular, we show sufficient conditions for uniqueness/multiplicity of harmonic functions associated to this type of operators.

Subharmonic solutions for a class planar systems of Volterra's type: a topological approach

Fabio Zanolin
University of Udine

We consider the problem of existence and multiplicity of subharmonic solutions to the planar differential system

$$x' = -\lambda\alpha(t)f(y), \quad y' = \lambda\beta(t)g(x), \tag{13}$$

where $f, g : \mathbb{R} \to \mathbb{R}$ are locally Lipschitz continuous functions with $f(0) = 0$, $f(s)s > 0$ for $s \neq 0$, $g(0) = 0$, $g(s)s > 0$ for $s \neq 0$ and such that at least one between f, g is bounded on $(-\infty, 0]$. Moreover, $\lambda > 0$ and $\alpha \gneq 0, \beta \gneq 0$ are T-periodic coefficients. The study of system (13) is motivated by the analysis of the Volterra predator-prey equation with periodic coefficients, but equations of this form appear also in the study of second-order ODEs with nonlinear differential operators of the form: $-\frac{d}{dt}(\varphi(t, u')) = g(t, u)$.
In this context, by a subharmonic solution of order $m \geq 2$, we mean a mT-periodic solution to system (13) which is not kT-periodic for all integers $k \in \{1, \dots, m-1\}$. Such solutions correspond to periodic points of the associated Poincaré map Φ, having m as a minimal period. In this talk, I will briefly present some different topological approaches to this problem and its applications to system (13).
The results presented in this talk are due to recent joint works with Julián López-Gómez and Eduardo Muñoz-Hernández of the Complutense university of Madrid.

Radial solutions for Pucci-Lane-Emden systems in annuli

Liliane Maia, Garielle Nornberg, Ederson Moreira dos Santos
Universidade de Brasília

In this talk we will present some recent results on existence of positive radial solutions in annuli for a class of nonlinear systems driven by Pucci extremal operators and Lane-Emden coupling in the superlinear regime. Our approach is purely nonvariational. It is based on the shooting method, energy functionals, spectral properties, and on a suitable criteria for locating critical points in annular domains through the moving planes method that we also adapt.

On elliptic Hamilton-Jacobi systems and Lane-Emden Hardy-Henon equations

Marta García-Huidobro, Marie Françoise Bidaut-Véron
Pontificia Universidad Católica de Chile

We will talk about the solutions of any sign of the system

$$\begin{cases} -\Delta u_1 = |\nabla u_2|^p, \\ -\Delta u_2 = |\nabla u_1|^q, \end{cases}$$

in a domain of $\mathbb{R}^N$, $N \gneq 3$ and $p, q > 0$, $pq > 1$.. We show their relation with Lane-Emden Hardy-Hénon equations

$$-\Delta_{\mathbf{p}}^{\mathbf{N}} w = \varepsilon r^{\sigma} w^{\mathbf{q}}, \qquad \varepsilon = \pm 1,$$

where $u \mapsto \Delta_{\mathbf{p}}^{\mathbf{N}} u$ $(\mathbf{p} > 1)$ is the $\mathbf{p}$-Laplacian in dimension $\mathbf{N}$, $\mathbf{q} > \mathbf{p} - 1$ and $\sigma \in \mathbb{R}$. This leads us to explore these equations in not often tackled ranges of the parameters $\mathbf{N}, \mathbf{p}, \sigma$. We make a complete

description of the radial solutions of the system and of the Hardy-Henon equations and give nonradial a priori estimates and Liouville type results.

Multiplicity of Solutions via magnitude changes

Pilar Herreros , Carmen Cortázar, Marta García-Huidobro
Pontificia Universidad Católica de Chile

We will study the radially symmetric solutions to the problem

$$\Delta u + f(u) = 0, \quad x \in \mathcal{R}^N, N > 2, \lim_{|x|\to\infty} u(x) = 0.$$

We will see that we can generate new solutions to this problem by introducing abrupt magnitude changes in the function f. Using this idea, we can construct functions f, defined by parts, such that the problem has any given number of solutions.

An existence result for Yamabe-type systems

Rayssa Helena Aires de Lima Caju
CMM

Our main goal is to study systems of Schrödinger equa- tions that, from the viewpoint of conformal geometry, are pure exten- sions of Yamabe-type equations. More specifically, we will discuss the existence and describe the asymptotic behavior of local solutions for strongly coupled critical elliptic systems near an isolated singularity. Such types of problems provide a natural connection between geometry and asymptotic analysis.

Joint work with João Marcos do Ó e Almir Santos.

Uniqueness and multiplicity of positive solutions to the scalar-field equation on large annuli in the three-dimensional unit sphere

Satoshi Tanaka, Noaki Shioji, Kohtaro Watanabe
Tohoku University

In this talk, we consider the Dirichlet problem

$$\Delta_{\mathbb{S}^3} u - u + u^p = 0 \ \text{ in } \Omega_\varepsilon; \quad u = 0 \ \text{ on } \partial\Omega_\varepsilon,$$

where $\Delta_{\mathbb{S}^3}$ is the Laplace-Beltrami operator on the three-dimensional unit sphere $\mathbb{S}^3$, $p > 1$, $0 < \varepsilon < \pi/2$, and Ω_ε is an annular domain in $\mathbb{S}^3$ whose great circle distance (geodesic distance) from the North Pole is greater than ε and less than $\pi - \varepsilon$. We obtain the existence, uniqueness, and multiplicity results of the positive solutions depend only on the latitude. This is joint work with Noaki Shioji (Yokohama National University) and Kohtaro Watanabe (National Defense Academy).

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Poster Section

Poster

Necessary and sufficient conditions for the continuity of inhomogeneous Calderón–Zygmund type operators in $h^p(\mathbb{R}^n)$

Claudio Vasconcelos, Galia Dafni, Chun Ho Lau, Tiago Picon
Universidade Federal de São Carlos

In this work we present necessary and sufficient cancellation conditions for the boundedness of inhomogeneous strongly singular Calderón–Zygmund operators in local Hardy spaces $h^p(\mathbb{R}^n)$ for $0 < p \leq 1$. Operators of this type are generalizations of *weakly-strongly multipliers* and include appropriate classes of pseudodifferential operators in the Hörmander class $OpS^m_{\sigma,\nu}(\mathbb{R}^n)$. The sufficiency relies on a new atomic and molecular decomposition of $h^p(\mathbb{R}^n)$, where the local vanishing moment condition is relaxed to an approximated one.

Joint work with Galia Dafni, Chun Ho Lau and Tiago Picon.

Mathematical analysis of fractional diffusion chemotaxis models

Crystianne Lilian de Andrade, Anne C. Bronzi
Universidade Estadual de Campinas

The Keller-Segel model is a system of partial differential equations that models chemotactic motion, that is the mechanism by which cells convert chemical signals into motion behavior. This system models the chemotactic aggregation phenomenon in cellular systems, which is mathematically viewed as a blow-up in finite time. It is known that the classical parabolic-parabolic system has blow-up solutions for sufficiently large initial conditions in dimensions $d \geq 2$, but in dimension one the solutions are globally regular. We consider a modified model in which the cellular diffusion and the chemical diffusion are modelled by fractional nonlocal operators with different exponents. We prove the existence of mild solution globally in time for initial condition with sufficient small L^p-norm. This is a joint work with Anne C. Bronzi.

Topological Signatures for Identifying and Classifying Oscillations

David Hien, Ulrich Bauer, Oliver Junge, Konstantin Mischaikow
Technical University of Munich

Nonlinear dynamical systems often exhibit rich and complicated recurrent dynamics. Understanding these dynamics is challenging, especially in higher dimensions where visualization is limited. To address this problem, we develope the topological notion of cycling which allows us to identify and classify oscillations in such systems.

The idea behind this is to generalize the observation that a trajectory segment γ is a periodic orbit if and only if $H_1(\gamma) \neq 0$. Replacing γ with metric thickenings in a suitable space, yields the cycling signature which captures the oscillations displayed by the segment.

Using tools from topological data analysis, cycling is computable for systems in moderately high dimensions. We demonstrate this through several examples. In particular, we identify and analyze 6 oscillations in a 4d system of ordinary differential equations.

On some parabolic problems in domains with small holes

Elaine Andressa Tavares de Lima, German Jesus Lozada Cruz
Universidade Estadual Paulista

In this work we study a class of parabolic problems in a domain with small holes whose size is proportional to a small positive parameter ε. For each ε fixed we prove the existence of global attractor in H_0^1. Also, we get the rate of the convergence of the resolvent operators when ε goes to zero.

Global ultradifferentiable hypoellipticity on compact manifolds

Eliakim Cleyton Machado, Fernando de Ávila Silva
Universidade Federal do Paraná

We study the global hypoellipticity problem for certain linear operators in Komatsu classes of Roumieu and Beurling type on compact manifolds. We present an approach by combining a characterization of these spaces via eigenfuction expansions, generated by an elliptic operator, and the analysis of matrix-symbols obtained by these expansions.

Geometric Estimates for Doubly Nonlinear Parabolic PDE's

Elzon Cézar Bezerra Júnior, João Vitor da Silva, Gleydson Chaves Ricarte
Universidade Estadual de Campinas

In this work we establish estimates of local Hölder regularity - in space and in time - for limited solutions of a given class of parabolic doubly degenerate PDE's, whose prototype equation is given by (m,p)-laplacian, i.e:

$$u_t - \operatorname{div}(m|u|^{m-1}|\nabla u|^{p-2}\nabla u) = f(x,t) \quad \text{em} \quad \Omega_T. \tag{14}$$

for $m \geq 1$, $p \geq 2$ and f belonging to a Lebesgue space with mixed norm. In addition to the inherently mathematical interest, this study is necessary, for example, in the analysis of turbulent filtration of a gas or a fluid in a porous medium, image analysis and groundwater problems. It is worth noting the cases $m = 1$ $(p > 2)$ and $p = 2$ $(m > 1)$, which represent, respectively, the p-Laplacian evolution and the porous media equation. Furthermore, we should not forget that the above equation also generalizes the heat equation when considering $m = 1$ and $p = 2$. In short, our approach is stable when, on the right, m tends to 1 and p tends to 2, which allows us to include the borderline cases $m = 1$ and/or $p = 2$. An intrinsic characteristic of the above equation is its law of degeneracy driven by a double non-linearity, whose "ellipticity modulus" collapses along the points where the solution is zero and the singular points of the same. Furthermore, such type of law of degeneracy suggests the use of intrinsic scaling and tangential techniques of geometric character adapted to our context. Thus, making use of these techniques we derive accurate regularity estimates for such models, which depend only on the problem data.

Results on the local well-posedness for a coupled system of mKdV type equations in $M_s^{2,p} \times M_s^{2,p}$

Fidel Cuba Balvin, Xavier Carvajal Paredes
Universidade Federal do Rio de Janeiro

We consider the initial value problem (IVP) associated to a system consisting modified Korteweg-de Vries (mKdV) type equations

$$(I)\begin{cases} \partial_t v + \partial_x^3 v + \partial_x(vw^2) = 0, & v(x,0) = \phi(x), \\ \partial_t w + \alpha\partial_x^3 w + \partial_x(v^2 w) = 0, & w(x,0) = \psi(x), \end{cases}$$

and using the theory of [1] we derive trilinear estimates and use it in mapping contraction principle [3] in IVP (I), so we study the local well-posedness (LWP) [2] for given data in modulation spaces $M_s^{2,p}(\mathbb{R}) \times M_s^{2,p}(\mathbb{R})$, $s > \frac{1}{4} - \frac{3}{2p}$, $2 \leq p < \infty$ and for $0 < \alpha < 1$.

References:

[1] T. OH, Y. WANG. On global well-posedness of the modified KdV equation in Modulation spaces. *Discrete and continuous Dynamical Systems*, 41: 2971-2992, 2021.

[2] X. CARVAJAL, M. PANTHEE. Nonlinear Schrodinger equations with the third order dispersion on Modulation spaces. *Partial Differential Equations and Aplications*, v.3, p. 59, 2022.

[3] A. GRUNROCK. An improved local well-posedness results for the modified KdV equation. *Int. Math. Res. Not.*, 3287-3308, 2004.

Orbital Instability of the Cnoidal Waves for the Cubic Nonlinear Klein-Gordon Equation

Guilherme de Loreno, Gabriel Bittencourt, Fábio Natali, Ademir Pastor
Universidade Estadual de Maringá

We establish an orbital stability result for cnoidal periodic waves to the cubic nonlinear Klein-Gordon equation. The spectral analysis for the corresponding linearized operator is established by using the Floquet theory and Morse index theorem. We prove that the cnoidal waves for the cubic Klein-Gordon equation are orbitally unstable in the energy space constituted by periodic functions with the mean zero property by a direct application of Grillakis, Shatah and Strauss' theory.

New Minimax Theorems for Lower Semicomntinuous Functions and Applications

Ismael Sandro da Silva, Claudianor Oliveira Alves, Giovanni Molica Bisci
Universidade Federal de Campina Grande

In this presentation we show a new version of the Bartsch's Fountain Theorem for a class of nonsmooth functionals that are sum of a C^1 functional and a convex lower semicontinuous functional, and also a version of a theorem due to Heinz for this class of functionals. The new abstract theorems are used to prove the existence of multiple solutions for some elliptical problems whose the associated energy functional is a semicontinuous functional of the above mentioned type.

Shadowing, topological entropy and recurrence of induced Morse-Smale diffeomorphism

Jennyffer Bohorquez, Alexander Arbieto
Universidade Federal de Ouro Preto

Let $f : M \to M$ be a Morse-Smale diffeomorphism defined on a compact and connected manifold without boundary. Let $C(M)$ denote the hyperspace of all subcontinua of M endowed with the Hausdorff metric and $C(f) : C(M) \to C(M)$ denote the induced homeomorphism of f. We show in this paper that if M is the unit circle S^1 then the induced map $C(f)$ has not the shadowing property. Also we show that the topological entropy of $C(f)$ has only two possible values: 0 or ∞. In particular, we show that the entropy of $C(f)$ is 0 when M is the unit circle S^1 and it is ∞ if the dimension of the manifold M is greater than two. Furthermore, we study the recurrence of the induced maps 2^f and $C(f)$ and sufficient conditions to obtain infinite topological entropy in the hyperspace.

From stochastic hamiltonian systems to stochastic compressible Euler equation

Jesus Manuel Correa Lora, Christian Horacio Olivera
Universidade Estadual de Campinas

For all $N \in \mathbb{N}$ we consider N the particles $\{X_N^i\}$ in $\mathbb{R}^d$ where the position X_N^k verifies

$$d^2X_N^k(t) = -\frac{1}{N}\sum_{l=1}^{N} \nabla\phi_N\left(X_N^k(t) - X_N^l(t)\right)dt + \varphi(X_N^k) \circ dB_t \quad k = 1, \cdots, N \tag{15}$$

where $\{B_t^i)_{t\in[0,T]},\ i \in \mathbb{N}\}$ is a family of standard $\mathbb{R}^d$-valued Brownian motions defined on a filtered probability space. Our aim is the study of the asymptotics as $N \to \infty$ of the time evolution of the whole system of all particles. Therefore, we investigate the empirical processes :

$$S_t^N := \frac{1}{N}\sum_{k=1}^{N} \delta_{X_N^k(t)}, \tag{16}$$

$$V_t^N := \frac{1}{N}\sum_{k=1}^{N} V_N^k(t)\delta_{X_N^k(t)} \tag{17}$$

where $dX_N^k(t) := V_N^k(t)dt$ is the velocity of the kth particle, and δ_a, denotes the Dirae measure at a. We shall prove that S_t^N and V_t^N converge as $N \to \infty$ to solutions of the continuity equation and the stochastic Euler equation, respectively.

Asymptotic behaviour of the heat equation in an exterior domain

Joaquín Domínguez de Tena, Aníbal Rodríguez Bernal
ICMAT-Universidad Complutense de Madrid

In this poster, I will present some results obtained in collaboration with Aníbal Rodríguez Bernal (UCM-ICMAT) regarding the asymptotic behaviour of the heat equation

$$\frac{\partial u}{\partial t}(x,t) - \Delta u(x,t) = 0 \qquad x \in \Omega,\ t > 0 \tag{18}$$

in a regular exterior domain, that is, a connected C^∞ set $\Omega \subset \mathbb{R}^N$ which is the complement of a compact set: $\Omega = \mathbb{R}^N \backslash C$. We call this compact set C *the hole*. Our goal is to study if the solutions **decay** and/or if they approach some **characteristic profile**. Here the **two main interacting mechanisms** are the diffusion, which tends to send mass to infinity, and the hole with its boundary conditions, which may absorb some mass. The boundary conditions that we consider are always homogeneous, but include Dirichlet, Robin and Neumann. Furthermore, we will cover three cases regarding the space the initial datum belongs to: $u_0 \in L^p(\Omega)$ where $1 < p < \infty$, $u_0 \in L^1(\Omega)$ and $u_0 \in L^\infty(\Omega)$.

Zeroes of solutions of fourth-order parabolic equations

Julia Pazzini, Phillipo Lappicy
Universidade Federal do Rio de Janeiro

This research analyzes a fourth order parabolic equation focusing on its curves of zeroes to find if the number of zeros increase and when it happens. In [1], the authors present a theorem that answer this question for a second order equation and we follow their path through the Newton polygon method and the knowledge acquired from [2] about higher-order equations.

References:

[1] S. Angenent and B. Fiedler. The dynamics of rotating waves in scalar reaction diffusion equations. *Trans. Amer. Math. Soc.*, 307, 545 – 568, (1988).

[2] V. Galaktionov. Sturmian nodal set analysis for higher-order parabolic equations and applications. *Adv. Diff. Eq.*, 12, 669–720, (2007).

On the 2D nonelliptic cubic Nonlinear Schrödinger Equation on RxT

Lindolfo Paul Mallqui Espinoza, Adán J. Corcho
Universidade Federal do Rio de Janeiro

This work is driven to discuss the non-elliptic cubic Nonlinear Schrödinger Equation

$$i\partial_t u + \Box u = \lambda |u|^2 u, \quad (x, y) \in \mathbb{R} \times \mathbb{T}, \tag{19}$$

where $\Box = \partial_x^2 - \partial_y^2$ and $\lambda = \pm 1$.

In the euclidean case $\mathbb{R} \times \mathbb{R}$, model (19) describes the gravity waves on the liquid surface and ion-cyclotron waves in plasma (see for instance [2]).

In [4], Yuzhao Wang showed that the Cauchy problem (19) is well-posed for initial data in the Sobolev space $H^s(\mathbb{T} \times \mathbb{T})$ with $s > 1/2$ and also he showed that the flux of the equation is not C^3 for $s < \frac{1}{2}$. For a similar model with the elliptic operator (Δ instead of $\Box$) it is known the following sharp well-posedness results:

- $H^s(\mathbb{R} \times \mathbb{R})$ with $s \geq 0$;
- $H^s(\mathbb{T} \times \mathbb{T})$ with $s > 0$ (see [1]);
- $L^2(\mathbb{R} \times \mathbb{T})$ for small data (see [3]).

In this work, adapting the ideas developed in [3], we derive a Strichart type estimate for the free operator of (19) on the cylinder $\mathbb{R} \times \mathbb{T}$ to obtain global well-posedness in $L^2(\mathbb{R} \times \mathbb{T})$ for small data. In other words, the dispersion in one of the directions allows us to get the same regularity as the one

obtained for the elliptic case in the cylinder, but the deduction of the Strichart type estimate in the non-elliptic case requires more technical care.

References:

[1] J. Bourgain. Exponential sums and nonlinear Schrodinger equations. *Geom. Funct. Anal.*, 3, 157-178 1993.

[2] E. A. Kuznetsov, S. K. Turitsyn. Talanov transformations in self-focusing problems and instability of stationary waveguides. *Physics Letters*, 112, 273-275 (1985).

[3] H. Takaoka and N. Tzvetkov. On 2D Nonlinear Schrödinger Equation with Data on $\mathbb{R}\times\mathbb{T}$. *Journal of Functional Analysis* ,182, 427-442 (2001).

[4] Y. Wang. Periodic cubic Hyperbolic Schrödinger Equation on $\mathbb{T}\times\mathbb{T}$. *Journal of Functional Analysis*, 265, 424-434 (2013).

Analysis of periodic solutions of impulsive NFDEs using the composite coincidence degree

Lucas Ozaki Mizuguti, Suzete Maria Silva Afonso
Universidade Estadual Paulista

The introduction of topological methods in the study of qualitative properties of differential equations proved to be a fruitful tool that gave birth to a myriad of results. Among these methods, one can mention the topological degree theory, which have been used in the study of qualitative properties of ODEs, PDEs, FDEs and FDEs with impulses, regarding existence, uniqueness and periodicity of solutions. It is worth mentioning that depending on the situation, we have topological degrees that are more suitable than others.

With this in mind, we use a topological degree theory called *composite coincidence degree*, introduced in 1993 by the mathematicians Erbe, Krawcewicz and Wu, to infer about the existence of periodic solutions for the impulsive NFDE

$$\begin{cases} \dfrac{d}{dt}(x(t)-A(t,x_t)) \;=\; g(t,x_t),\ t\neq t_k,\ k\in \boldsymbol{Z} \\ x(t_k^+)-x(t_k) \;=\; b_k x(t_k),\ t=t_k,\ k\in \boldsymbol{Z}. \end{cases}$$

Unique continuation and decay for a higher order water wave model.

Miguel Dario Soto Vieira, Ademir Fernando Pazoto
Universidade Federal do Rio de Janeiro

This work is devoted to prove the exponential decay for the energy of solutions of a higher order Korteweg -de Vries (KdV)–Benjamin-Bona-Mahony (BBM) equation on a periodic domain with a localized damping mechanism. Following the method in [2], which combines energy estimates, multipliers and compactness arguments, the problem is reduced to prove the Unique Continuation Property (UCP) for weak solutions of the model. Then, this is done by deriving Carleman estimates for a system of coupled elliptic-hyperbolic equations.

References:

[1] J. L. Bona, X. Carvajal, M. Panthee and M. Scialom. Higher-order Hamiltonian model for undirectional water waves. *J. Nonlinear Sci.*, 28 (2018), 543–577.

[2] L. Rosier and B. Y. Zhang. Unique continuation property and control for the Benjamin-Bona-Mahony equation on a periodic domain. *J. Differential Equations*, 254 (2013), 141–178.

The One-Point neutron branching process simulation.

Nilson Costa Roberty, Lucas Schmidt Ferreira de Araujo
Universidade Federal do Rio de Janeiro

We approach the one-point kinetics Equations from Nuclear Reactor Theory making use of results of the Branching Process Theory. Since the investigated process is punctual, that is, particles are characterized only by its birth and death time, the basics Backaward and Forward Kolmogorov Equation are derived in therms of the so called generation function. It is also shown analytical relations between both equations.

After equation deductions, first and second moments of the generation function are analytically computed and compared with results from the developed Generator Project, a branching process Monte Carlo simulator implemented on high performance programming language. Computational estimation of the so called extinction probability is also compared with analytical equations.

The work concludes presenting a numerical parameter analysis of the tree-branching algorithm implemented on the project and an explanation for its limitations, illustrated by the Pseudo-Catastrophe Phenomena.

Four-dimensional zero-Hopf bifurcation for a Lorenz-Haken system

Pedro Iván Suárez Navarro, Sonia Isabel Renteria Alva
Universidad Nacional José María Arguedas

In this paper, we consider a four-dimensional Lorenz-Haken system $\dot{x} = a(y-x)$, $\dot{y} = -cy - dz + (e-w)x$, $\dot{z} = dy - cz$, $\dot{w} = -bw + xy$, where a, b, c, d and e are real parameters. We characterize the values of the parameters for which a zero-Hopf equilibrium point takes place at the singular points and shows the existence of periodic orbits bifurcating these points, as well as, the stability conditions of periodic solutions are given. The principal tool is the averaging theory.

A global result for a degenerate quasilinear eigenvalue problem with discontinuous nonlinearities

Pedro Fellype da Silva Pontes, Jefferson Abrantes dos Santos, Sérgio H. Monari Soares
Universidade Federal de Campina Grande

In this work we considers a class of degenerate quasilinear elliptic equations with discontinuous nonlinearities. The existence of positive weak solutions and S-solutions is discussed using variational methods. The results assert that the (λ, a)-space of the parameters involved is divided into three regions - no solution, at least one S-solution, and at least two weak solutions (one is S-solution among them), in each region respectively. The regions are separated by a continuous, nondecreasing curve and line segment. Further, there exists an S-solution at each point on the separating curve.

Existence of heteroclinic and Saddle type solutions for a class of quasilinear problems in whole $\mathbb{R}^2$

Renan Jackson Soares Isneri, Claudianor Oliveira Alves, Piero Montecchiari
Universidade Federal de Campina Grande

In this presentation we use variational methods to prove the existence of heteroclinic and saddle type solutions for a class quasilinear elliptic equations of the form

$$-\Delta_\Phi u + A(x,y)V'(u) = 0 \text{ in } \mathbb{R}^2,$$

where $\Phi : \mathbb{R} \to [0,+\infty)$ is a N-function, $A : \mathbb{R}^2 \to \mathbb{R}$ is a periodic positive function and $V : \mathbb{R} \to \mathbb{R}$ is modeled on the Ginzburg Landau potential. In particular our main result includes the case of the potential $V(t) = \Phi(|t^2 - 1|)$, which reduces to the classical double well Ginzburg-Landau potential when $\Phi(t) = |t|^2$, that is, when we are working with the Laplacian operator.

This is joint work with Claudianor O. Alves and Piero Montecchiari and is based on paper C. O. Alves, R. Isneri and P. Montecchiari, *Existence of heteroclinic and Saddle type solutions for a class of quasilinear problems in whole* $\mathbb{R}^2$, Communications in Contemporary Mathematics (2022).

Sharp Hessian estimates for solutions to fully nonlinear obstacle problem with natural growth and unbounded ingredients

Romário Tomilhero Frias, João Vitor da Silva
Universidade Estadual de Campinas

In this work we establish existence, uniqueness and regularity for L^p-viscosity solutions to fully nonlinear obstacle problem with super-linear growth on the gradient entry and unbounded ingredients. In our findings we obtain $W^{2,p}_{loc}$ estimates for such solutions with $\frac{N}{2} < p_0 < p < \infty$.

Piecewise smooth vector fields modeling intermittent cancer and HIV treatment

Tiago Carvalho
Universidade de São Paulo

In this work we present the dynamics of some recent models of intermittent cancer and HIV treatment. The piecewise smooth dynamic is obtained from the qualitative point of view. Limit sets and bifurcations are described.

A singular perturbation problem governed by normalized p(x)-Laplacian

Víctor Antonio Blanco Viloria
Universidade Estadual de Campinas

In this work we will focus our attention on finding a family of solutions (in the viscosity sense) $(u_\varepsilon)_{\varepsilon>0}$ for a singularly perturbed problem driven governed by normalized $p(x)$-Laplacian. Assuming suitable assumptions on the data we will show that such solutions enjoy certain properties, such as uniform boundedness, local Lipschitz regularity and non-degeneracy in a smooth domain $\Omega \subset \mathbb{R}^n$. Furthermore, by using the stability of notion of viscosity solutions, we will show, up to a subsequence, that $\lim_{j\to\infty} u_{\varepsilon_j} = u_0$, which becomes a solution of a one-phase free problem of Bernoulli type. Our results are natural extension to the ones in [2] and [4].

References:

[1] A. Arroyo, J. Heino, M. Parviainen. Tug-of-war games with varying probabilities and the normalized $p(x)-$Laplacian. *Commun. Pure Appl. Anal.*, 16 (3), 915-944 (2017).

[2] E. C. Bezerra Júnior, J. V. da Silva, G. C. Ricarte. Fully nonlinear singularly perturbed models with non-homogeneous degeneracy. *Rev. Mat. Iberoam.*, (2022), published online first DOI 10.4171/RMI/1319.

[3] J. V. da Silva, V. A. B. Viloria. A singular perturbation problem for the normalized $p(x)$-Laplacian operator. 2022, [In Preparation].

[4] G. C. Ricarte, J. G. Araújo. Up-to boundary regularity for a singular perturbation problem of $p-$Laplacian type equations in non-divergence form . *Nonlinear Analysis*, 188, (2019) 339-361.

[5] J. Siltakoski. Hölder gradient regularity for the inhomogeneous normalized $p(x)-$Laplace equation . *Journal of Mathematical Analysis and Applications*, 1513, (2022), 126-187.

13th Americas Conference on Differential Equations and Nonlinear Analysis & the ICMC Summer Meeting on Differential Equations 2023 Chapter

Programme

(*) remote lecture

13th Americas Conference on Differential Equations and Nonlinear Analysis &
ICMC Summer Meeting on Differential Equations - 2023 Chapter

In Memory of James Muldowney and Geneviève Raugel

Schedule Overview

	MONDAY 30	TUESDAY 31	WEDNESDAY 01	THURSDAY 02	FRIDAY 03
08:00-08:30	**Registration**				
08:30-09:00	**Opening**				
Auditorium	**PLENARY LECTURES**				
Chair	José M. Arrieta	K. Mischaikow	Raul Manasevich	Jaqueline Mesquita	Tomás Caraballo
09:00-09:50	**Mónica Clapp**	**Carina Curto**	**Irene Fonseca**	**Isabeau Birindelli**	**José M. Arrieta**
09:50-10:40	**Yingfei Yi**	**Marcone Pereira**	**J-P Lessard**	**Maria J. Pacifico**	**Renato Iturriaga**
10:40-11:00	Coffee Break				
11:00-13:00	**Sessions 1-7**	**Sessions 1-7**	**Sessions 1, 8-14**	**Sessions 1, 7, 8-14**	**Sessions 8-14**
13:00-14:30	Lunch				
14:30-15:00	**Poster Session**				
Auditorium	**PLENARY LECTURES**				
Chair	Yingfei Yi	J-P Lessard	Isabeau Birindelli	Mónica Clapp	Marcone Pereira
15:00-15:50	**J. Mallet-Paret***	**Tomás Caraballo**	**Raul Manasevich**	**Jaqueline Mesquita**	**Hugo Leiva**
15:50-16:10	Coffee Break				
16:10-18:10			**Sessions 1-7**		
16:10-17:40	**Mini-Courses 1-4**	**Mini-Courses 1-5**		**Mini-Courses 1-5**	**Mini-Courses 1-5**
	SOCIAL EVENTS				
10:40			**Photo**		
20:00			**Conference Banquet**		

(*) remote lecture

Session 1 – Conservation Laws and Transport Equations
Session 2 – Elliptic Equations
Session 3 – Free Boundaries Problems and Related Topics
Session 4 – Integral and Functional Differential Equations
Session 5 – Linear Equations
Session 6 – Multiscale Dynamics
Session 7 – Nonlinear Dynamical Systems
Session 8 – Computational Dynamics
Session 9 – Dispersive Equations
Session 10 – Domain Perturbations PDEs and Dynamics
Session 11 – Dynamical Systems and Ergodic Theory
Session 12 – Fluid Dynamics
Session 13 – Harmonic Analysis and Related Topics
Session 14 – Nonlinear Boundary Value Problems

Mini-Course 1 - Applied Bifurcation Theory
Mini-Course 2 - Computing the Global Dynamics of Parameterized Systems of ODEs
Mini-Course 3 - Life Science Models, Data Implementation and Related Topics
Mini-Course 4 - PDE Techniques Applied to Game Theory
Mini-Course 5 - Random Dynamical Systems

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13th Americas Conference on Differential Equations and Nonlinear Analysis &
ICMC Summer Meeting on Differential Equations - 2023 Chapter

In Memory of James Muldowney and Geneviève Raugel

Thematic Sessions

	MONDAY 30	TUESDAY 31	WEDNESDAY 01	THURSDAY 02	FRIDAY 03
Room 5-004	**Session 1 – Conservation Laws and Transport Equations**				
Chair	Wladimir Neves	Jean Silva	Daniel Marroquin	Joao Nariyoshi	
11:00-11:30	**Grigori Chapiro**	**Aparecido Souza**	**Claudia Espitia**	**Paulo Amorim**	
11:30-12:00	**Aldo Bazan**	**Lauren Bonaldo**	**Julio Guevara***	**Yuliia Petrova**	
Chair	Gerardo Huaroto	Aldo Bazan	Grigori Chapiro	Lauren Bonaldo	
12:00-12:30	**Daniel Marroquin**	**João Nariyoshi**	**Juliana Ziebell**	**Luís F. Salvino**	
12:30-13:00	**Richard De la Cruz**	**Henrique Souza**	**Nikolai Chemetov**	**Gerardo Huaroto**	
Room 5-001	**Session 2 – Elliptic Equations**				
Chair	Marcos Pimenta	Ederson M. Santos			
11:00-11:30	**Claudianor Alves**	**Olímpio Miyagaki**			
11:30-12:00	**Sigifredo Herrón**	**Gabrielle Nornberg**			
12:00-12:30	**João Rodrigues**	**Clara Patriarca**			
Chair			Eugenio Massa		
16:10-16:40			**Alessio Falocchi**		
16:40-17:10			**Alânnio Nóbrega**		
17:10-17:40			**Mayra Soares**		
17:40-18:10			**Pêdra Andrade***		
Room 5-003	**Session 3 – Free Boundaries Problems and Related Topics**				
Chair	João Vitor da Silva	Mariana Smit Vega Garcia			
11:00-11:30	**Mariana Smit Vega Garcia***	**Hui Yu***			
11:30-12:00	**Héctor Chang-Lara***	**Pêdra Andrade***			
12:00-12:30	**Damião Araújo**	**Edoardo Bocchi**			
Chair			Disson dos Prazeres		
16:10-16:40			**Eduardo Teixeira***		
16:40-17:10			**Diego Moreira**		
17:10-17:40			**Leandro Tavares**		
Room 5-101	**Session 4 – Integral and Functional Differential Equations**				
Chair	Jaqueline Mesquita	Everaldo Bonotto			
11:00-11:30	**Everaldo Bonotto**	**Piotr Kalita**			
11:30-12:00	**Rocio Balderrama**	**Xiaoying Han**			
12:00-12:30	**Gonzalo Robledo**	**Junya Nishiguchi**			
Chair			Piotr Kalita		
16:10-16:40			**Fernanda Andrade**		
16:40-17:10			**Claudio Gallegos**		
17:10-17:40			**Teresa Faria***		
Room 5-103	**Session 5 – Linear Equations**				
Chair	Gabriel Araújo	Igor Ferra			
11:00-11:30	**Joel Coacalle**	**Wagner de Moraes**			
11:30-12:00	**Renan Medrado**	**Giuliano Zugliani**			
12:00-12:30	**Luis Ragognette**	**Fernando de Ávila**			
Chair			Bruno de Lessa		
16:10-16:40			**Stefan Fürdös**		
16:40-17:10			**Tiago Picon**		
17:10-17:40			**Pedro Lopes**		

(*) remote lecture

Thematic Sessions (cont.)

	MONDAY 30	TUESDAY 31	WEDNESDAY 01	THURSDAY 02	FRIDAY 03
Room 5-104	**Session 6 – Multiscale Dynamics**				
Chair	Zhongwei Shen	Paulo Ruffino			
11:00-11:30	**Paulo Ruffino**	**Paulo H. da Costa**			
11:30-12:00	**Weiwei Qi**	**Luis Venegas**			
12:00-12:30	**Alberto Ohashi**	**Yao Li**			
Chair			Yao Li		
16:10-16:40			**Shirou Wang**		
16:40-17:10			**Gerardo Vargas**		
17:10-17:40			**Zhongwei Shen**		
Auditorium	**Session 7 – Nonlinear Dynamical Systems**				
Chair	Juliana Fernandes	Estefani Moreira		Matheus Bortolan	
11:00-11:30	**Estefani Moreira**	**Alexandre Oliveira Sousa**		**Nataliia Goloshchapova**	
11:30-12:00	**Matheus Bortolan**	**Juliana Fernandes**		**Maurizio Garrione**	
12:00-12:30	**Jacson Simsen**	**Leonardo Pires**		**To Fu Ma**	
12:30-13:00	**Sergio Oliva**	**Arnaldo do Nascimento**			
Chair			Phillipo Lappicy		
16:10-16:40			**Pablo Castañeda***		
16:40-17:10			**Bjorn Sandstede***		
17:10-17:40			**Phillipo Lappicy***		
Room 5-002	**Session 8 – Computational Dynamics**				
Chair			K. Mischaikow	Marcio Gameiro	
11:00-11:30			**Katherine Morrison***	**Shane Kepley***	
11:30-12:00			**Oliver Junge**	**Ewerton Vieira**	
12:00-12:30			**Bogdan Batko**	**Dahisy Lima**	
Room 5-104	**Session 9 – Dispersive Equations**				
Chair			Mahendra Panthee	Xavier Carvajal	Marcia Scialom
11:00-11:30			**Ademir Pastor**	**Adán Corcho**	**Xavier Carvajal**
11:30-12:00			**Renata Figueira**	**Gabriel Moraes**	**Halit Aslan**
12:00-12:30			**Marcelo Nogueira**	**Andressa Gomes**	**Mahendra Panthee**
12:30-13:00			**Argenis Mendez**	**José Raul Quintero**	**Luiz G. Farah**
Room 5-001	**Session 10 – Domain Perturbations, PDEs and Dynamics**				
Chair			Marcone Pereira	José M. Arrieta	Antonio L. Pereira
11:00-11:30			**Maria E. Pérez**	**Antonio L. Pereira**	**Rafael Orive**
11:30-12:00			**Marko Radulovic**	**Silvia Sastre Gómez**	**Jean C. Nakasato**
12:00-12:30			**Alessandra Verri**	**Joaquín Domínguez**	**Marcus Marrocos**
Room 5-102	**Session 11 – Dynamical Systems and Ergodic Theory**				
Chair			Daniel Smania	Maria J. Pacífico	
11:00-11:30			**Cristina Lizana**	**Adriana da Luz**	
11:30-12:00			**Gabriel Ponce**	**Ricardo Bortolotti**	
12:00-12:30			**Adriana Sánchez**	**Graccyela Salcedo**	
12:30-13:00			**Benito Pires**	**Catalina Freijo**	
Room 5-101	**Session 12 – Fluid Dynamics**				
Chair			Anne Bronzi	Gabriela Planas	Juliana Honda
11:00-11:30			**Gabriela Planas**	**Anne Bronzi**	**Nikolai Chemetov**
11:30-12:00			**Cilon Perusato**	**Juliana Lopes**	**Milton Lopes Filho**
12:00-12:30			**Leithold Alvarez***	**Edison Huamani**	**Helena Nussenzveig Lopes**

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In Memory of James Muldowney and Geneviève Raugel

Thematic Sessions (cont.)

	MONDAY 30	TUESDAY 31	WEDNESDAY 01	THURSDAY 02	FRIDAY 03
Room 5-103	**Session 13 – Harmonic Analysis and Related Topics**				
Chair			Tiago Picon	Lucas Oliveira	Guilherme Silva
11:00-11:30			**Carlos Perez**	**Felipe Gonçalves**	**Mateus de Sousa**
11:30-12:00				**Guilherme Silva**	**Ryan Gibara**
12:00-12:30			**Lucas Oliveira**	**Victor Biliatto**	**Zeinab Ashtab***
12:30-13:00			**Marcelo de Almeida**	**Luís Salge**	
Room 5-003	**Session 14 – Nonlinear Boundary Value Problems**				
Chair			Marta Garcia-Huidobro	Gabrielle Nornberg	Raúl Manásevich
11:00-11:30			**Boyan Sirakov***	**Liliane Maia**	**Marta García-Huidobro**
11:30-12:00			**Fabio Zanolin***	**Elisandra Gloss**	**Briceyda Delgado**
12:00-12:30			**Denis Bonheure***	**Erwin Topp**	**Rayssa Caju***
12:00-12:30			**Satoshi Tanaka***	**Pilar Herreros**	**Diego Moreira**

(*) remote lecture

Mini-Courses

	MONDAY 30	TUESDAY 31	WEDNESDAY 01	THURSDAY 02	FRIDAY 03
Room 5-001	**Mini-course 1 – Applied Bifurcation Theory**				
Chair	Yingfei Yi				
16:10-17:40	**Sue Ann Campbell**	**Sue Ann Campbell**		**Sue Ann Campbell**	**Sue Ann Campbell**
Room 5-003	**Mini-course 2 – Computing the Global Dynamics of Parameterized Systems of ODEs**				
Chair	J-P Lessard				
16:10-17:40	**K. Mischaikow and M. Gameiro**	**K. Mischaikow and M. Gameiro**		**K. Mischaikow and M. Gameiro**	**K. Mischaikow and M. Gameiro**
Room 5-004	**Mini-course 3 – Life Science Models, Data Implementation and Related Topics**				
Chair	Sergio Oliva				
16:10-17:40	**Michael Li**	**Michael Li**		**Michael Li**	**Michael Li**
Room 5-101	**Mini-course 4 – PDE Techniques Applied to Game Theory**				
Chair	Marcone Pereira				
16:10-17:40	**Nicolas Saintier**	**Nicolas Saintier**		**Nicolas Saintier**	**Nicolas Saintier**
Room 5-103	**Mini-course 5 – Random Dynamical Systems**				
Chair		Tiago Pereira			
16:10-17:40		**Jeroen Lamb**		**Jeroen Lamb**	**Jeroen Lamb**
Auditorium entrance	**Poster Session**				
14:30-15:00					
	Ismael da Silva	**Claudio Vasconcelos**	**David Hien**	**Crystianne Andrade**	**Fidel Cuba**
	Jesus Correa Lora	**Eliakim Machado**	**Elaine de Lima**	**Jennyffer Bohorquez**	**Guilherme Loreno**
	Lucas Mizuguti	**Elzon Bezerra**	**Joaquín Domínguez**	**Pedro Suárez**	**Lindolfo Mallqui**
	Pedro Pontes	**Romário Frias**	**Julia Pazzin**	**Tiago Carvalho**	**Miguel Soto**
	Renan Isneri	**Victor Viloria**	**Nilson Roberty**		

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List of Speakers

List of speakers (ordered by first name)

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