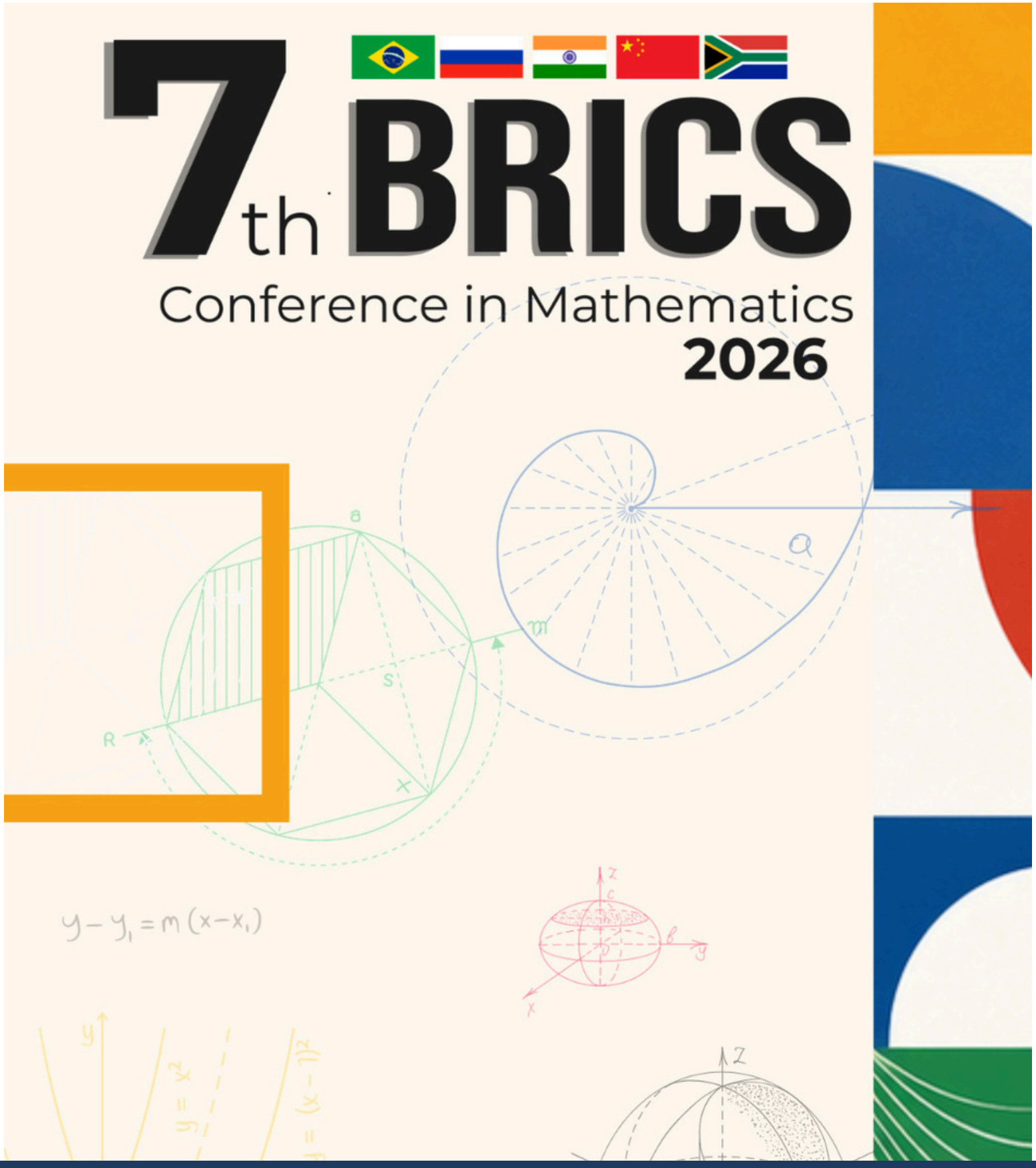
7th BRICS

Conference in Mathematics

2026



Book of abstracts

São Paulo, Brazil - August 18-21

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General Information

About the Event

The **BRICS Mathematics Conference** is a premier international scientific forum that unites the mathematical communities of Brazil, Russia, India, China, and South Africa. As a vital institutional space for dialogue, the conference fosters scientific cooperation, strengthens academic ties, and builds joint initiatives across the BRICS nations' leading universities and research centers.

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Distinguished Lecture

Distinguished Lecture

Julia sets of positive Lebesgue measure in dimensions one and two

Artur Ávila

IMPA, Brazil

T. B. A.

Plenary Lectures

Plenary Lectures

Limiting spectral distribution of (symmetric) random matrices with independent entries

Arup Bose

Indian Statistical Institute, Kolkata, India

It is well known that the limit eigenvalue distribution of the scaled standard Wigner matrix is the semi-circular distribution whose $2k$th moment equals the number of non-crossing pair-partitions of $\{1, 2, \ldots, 2k\}$. There are several specific extensions of this result in the literature, including the sparse case. We discuss a broad extension by relaxing significantly the 'independent identically distributed" assumption for random entries of the matrix. The limiting spectral distributions then involve a larger class of partitions. In the process we show how some new sets of partitions gain importance. Several existing and new results for their band and sparse versions, as well as for matrices with continuous and discrete variance profile follow as special cases.

Topology of integrable systems on 4- and 6-manifolds

Elena Kudryavtseva

Moscow State University, Moscow, Russia

The talk is about topology of integrable Hamiltonian systems on 4- and 6-manifolds. From a topological point of view, an integrable Hamiltonian system can be treated as a singular Lagrangian fibration on a smooth symplectic 2n-manifold whose generic fibres are n-dimensional tori. By a singularity, we mean either a singular point or a singular fiber of the fibration. The topological structure of such singularities is very important for understanding the dynamics of integrable systems both globally and locally. We assume that the integrable system is real-analytic. We study only such singularities that are persistent (stable) under small integrable perturbations. This

is one of the reasons why such singularities can be observed in many examples of integrable Hamiltonian systems (e.g. Kovalevskaya top and other integrable cases in rigid body dynamics). We describe topological invariants of such singularities and obtain their classification up to fibrewise homeomorphism (for time being we forget about symplectic structure). Then we combine these singularities together to describe the global structure of the fibration.

The Power of Polynomial Invariants: From Colouring to Entanglement

Eunice Mphako-Banda

University of the Witwatersrand, South Africa

Some of the most profound ideas in mathematics arise from very simple questions: how can we distinguish objects, recognize hidden patterns, or uncover the principles that unite seemingly unrelated areas in mathematics? Polynomial invariants provide one of the most elegant answers. Encoded within a single polynomial can be a wealth of combinatorial, geometric, and topological information, revealing structure that is often invisible at first glance.

This lecture celebrates the remarkable journey of some polynomial invariants through modern mathematics. From counting colourings to distinguishing knots, these polynomials have unveiled connections between discrete mathematics and topology.

Rather than focusing on technical details, this talk will explore the stories behind these remarkable invariants: why they were discovered, what makes them so powerful, and how they continue to inspire new mathematics. In particular, we will focus on the chromatic and the Tutte polynomials. Finally, we will show how the Tutte polynomial can capture deep structural truths and serve as a bridge between graph theory and knot theory.

[1] C.C. Adams, The knot book, W.H.Freeman and Company, New York, 1994.

[2] F.M. Dong, K.M. Koh and K. L. Teo, Chromatic polynomials and chromaticity of graphs, World Scientific, New Jersey 2005.

[3] E.G. Mphako, The component number of links from graphs, Proc. Edin. math soc., 45: 723-730 (2002).

[4] T. W. Tutte, On dichromatic polynominals, J. Combin. Theory, 2: 301- 320 (1967).

Coexistence of hyperbolicity of different types

Katrin Gelfert

Universidade Federal do Rio de Janeiro, UFRJ, Brazil

Hyperbolic dynamical systems are characterized by uniform contraction in stable directions and uniform expansion in unstable directions, with the Smale horseshoe as a classical example. Our interest, however, is in non-hyperbolic systems, where contraction and expansion interact to produce neutral dynamics.

We study a class of skew products over a horseshoe with fiber maps given by two circle diffeomorphisms. A particularly important family arises from the projective actions of matrices in $SL(2, R)$, especially when one matrix is hyperbolic and the other elliptic. This framework naturally combines a partially hyperbolic dynamical system, with stable, unstable, and central directions, and a matrix cocycle.

The Lyapunov exponent in the central direction equals the exponential growth rate of the associated matrix products. We discuss the spectrum of these exponents through thermodynamic formalism and the geometry of the space of ergodic measures, highlighting the role of non-hyperbolic measures and presenting some recent results. *Co-authors:* L.J.Díaz, M.Rams, and J. Zhang.

Flows in networked domains: mathematical insights from hyperbolic conservation laws

Mapundi K. Banda

University of Pretoria, South Africa

The movement of mass, energy, information, and resources through interconnected networks underpins modern society, from natural gas transmission and water distribution to transportation and integrated energy systems. Despite their diversity, these applications share a common mathematical foundation in the dynamics of flows on networks, at the intersection of networked infrastructure, hyperbolic conservation laws, and scientific computing. The formulation and analysis of flow problems on networks present unique mathematical challenges that require innovative modelling, analytical, and computational techniques. Drawing on representative examples, how advances in transient flow modelling have generated new mathematical insights and efficient computational methods will be demonstrated while at the same time demonstrating how hyperbolic conservation laws provide a unifying framework for understanding complex networked systems across engineering and the applied sciences. In conclusion, opportunities that arise from the seamless integration of mathematical theory, computation, optimization, control, and data will be demonstrated.

Digital twins of ultrasound tomography

Maxim A. Shishlenin

Institute of Computational Mathematics and Mathematical Geophysics, Novosibirsk, Russia

The development of methods for the early diagnosis of soft tissue malignancies is one of the key problems of modern medicine. The absence of exposure to ionized radiation distinguishes ultrasound tomography (UT) from mammography, CT, and MRI. Currently, ultrasound tomographs are being developed at QT Imaging, MIT (USA), Radboud University (the Netherlands), University College London (Great Britain), but there is no commercially manufactured tomograph. The report will present UT data processing methods developed by our scientific group: kinematic, frequency, dynamic, neural networks and a digital prototype of the UT.

Domination in Regular Graphs

Michael A. Henning

University of Johannesburg, Johannesburg, South Africa

A set S of vertices in a graph G is a dominating set of G if every vertex in $V(G) \setminus S$ is adjacent to a vertex in S, and S is a total dominating set if every vertex in $V(G)$ is adjacent to a vertex in S. An independent dominating set in G is a dominating set of G with the additional property that it is an independent set. The parameters $\gamma(G)$, $\gamma_t(G)$ and $i(G)$ are the minimum cardinalities among all dominating, total dominating and independent dominating sets in G, respectively. An r-regular graph is a graph in which every vertex has degree r. We prove (see [4]) an asymptotic upper bound on the domination number of an r-regular graph for r sufficiently large. Among other results, we prove the $\frac{3}{8}$-conjecture for independent domination (see [1]) which states that if G is connected 3-regular graph of order n different from $K_{3,3}$ and the 5-prism $C_5 \,\square\, K_2$, then $i(G) \leq \frac{3}{8}n$. The $\frac{1}{3}$-conjecture for domination states that if G is a 4-regular graph of order n, then $\gamma(G) \leq \frac{1}{3}n$. We prove the $\frac{1}{3}$-conjecture for domination when the 4-regular graph has no induced 4-cycle (see [1]). A thorough treatise on dominating sets can be found in [2].

[1] B. Brešar, T. Dravec, and M. A. Henning, A proof of the $\frac{3}{8}$-conjecture for independent domination in cubic graphs, mansucript.

[2] T. W. Haynes, S. T. Hedetniemi, and M. A. Henning, *Domination in Graphs: Core Concepts* Series: Springer Monographs in Mathematics, Springer, Cham, 2023. xx + 644 pp.

[3] M. A. Henning and A. Yeo, Domination in 4-regular graphs with no induced 4-cycles. *J. Graph Theory* **112** (2026), 62–95.

[4] M. A. Henning and P. Horn, Optimal linear-Vizing relationships for (total) domination in graphs. *J. Graph Theory* **106** (2024), no. 1, 149–166. *Co-authors:*

Profinite properties of residual finite groups and profinite genus

Pavel Zalesski

Universidade de Brasília, Brazil

I shall define profinite property for residually finite groups and give examples of profinite properties for groups of geometric nature. Then I shall define the notion of genus and give some results on genus for free constructions.

A Century of Discretizing the Atmosphere: Numerical Methods in Weather and Climate Models, and the Role of BRICS

Pedro da Silva Peixoto

University of São Paulo, Brazil

Weather forecasting and climate modeling stand among the great achievements of applied mathematics and scientific computing, evolving for over a century in tandem with advances in the numerical analysis of partial differential equations. This talk traces that mathematical evolution: from Lewis Fry Richardson's 1922 hand computation and the stability condition it exposed, through the first electronic forecasts led by von Neumann's group in the 1950s, to the spectral transform methods that dominated global models through the 1990s. We then discuss the shift toward quasi-uniform spherical discretizations that sought to address computational challenges on exascale computers, alongside the more recent rise of data-driven, machine-learned weather emulators trained on reanalysis data. Throughout, we emphasize the numerical-analysis questions driving each transition. We close by examining where BRICS nations currently stand and look: Brazil's community model MONAN on spherical Voronoi grids; China's grid-point CMA-GFS alongside a fast-growing family of transformer- and diffusion-based AI emulators; India's newly homegrown Bharat Forecast System, which instead pushes a spectral triangular-cubic-octahedral grid to convection-permitting resolution; and Russia's traditional semi-Lagrangian SL-AV model, alongside an emerging generative AI successor. We discuss what this methodological diversity suggests for BRICS mathematical collaboration in Earth system prediction.

Non-normality, translation-rotation coupling and chaos in particle-laden flow

Rama Govindarajan

International Centre for Theoretical Sciences Tata Institute of Fundamental Research
Shivakote, Bengaluru, India

Small particles suspended in a flow are often approximated to be spherical. In this talk we will discuss three ways in which departure from sphericity changes the behaviour fundamentally. A linearly stable system asymptotically displays exponential decay of perturbations, but such a system can display transient algebraic growth when the stability matrix is non-normal. This happens with a row of ellipsoids sedimenting under gravity in the Stokes limit. A departure from an ellipsoidal shape is even more interesting. Di-bilaterals, or bodies with two planes of symmetry, can display quasiperiodic motion due to a coupling between translation and rotation. In potential flow, triaxial ellipsoids can display chaotic motion and we will explore this.

Optimization with Least Constraint Violation

Yu-hong Dai

Academician of Chinese Academy of Sciences, China

Feasibility is a fundamental issue in the field of both continuous optimization and discrete optimization, no matter whether the problem is feasible or not feasible. Even if the optimization problem is feasible, state-of-the-art solvers have to deal with infeasible subproblems and may generate infeasible cluster points. In this talk, I shall summarize recent advances on optimization with least constraint violation and related applications and give some discussions.

Space of rational curves on rationally connected varieties

Zhiyu Tian

Peking University, China

Different groups of mathematicians in number theory, algebraic geometry and symplectic geometry have made their predictions about asymptotic behaviors of the space of rational curves on rationally connected varieties (a very interesting class of varieties introduced by Kollár-Miyaoka-Mori in the 90's). Through the effort of many people, we now have a better understanding of the problem. In this talk, I will explain some of the ideas behind these predictions, further conjectures arising from them, and some recent progress.

Invited Lectures

Invited Lectures

BRICS Mathematics: A Journey of History, Collaboration, and Future

Jinyun Yuan

Universidade Federal do Paraná, Brazil

Given short description on mathematics history of five main countries of the BRICS group. Also recall BRICS Math Conference development. Some personal opinion on the future cooperation of BRICS group on Mathematics, specially some suggestions for BRICS Mathemtics Union (BMU).

Inverse Problems and Neural Network

Sergey I. Kabanikhin

Abstract

Life Just Outside Linearity: An Introduction to Near-vector Spaces

Karin-Therese Howell

African Institute for Mathematical Sciences (AIMS) South Africa

Near-vector spaces arise from weakening one of the distributive laws in the definition of a vector space, placing them in the rich and often surprising world "just outside" linear algebra. Although they retain many familiar features of vector spaces, they also exhibit behaviour that is distinctly non-linear. In this talk, I will introduce the basic ideas behind near-vector spaces, focusing primarily on André's influential formulation of the theory

[1]. The talk is intended as an accessible introduction to the subject, aimed at a broad mathematical audience. My goal is to show how relaxing a single familiar axiom opens the door to a surprisingly rich collection of phenomena and raises new questions about what "linearity" really means.

[1] J. André, Lineare Algebra uber Fastk orpern, Math. Z. 136 (1974), 295–313.

Zeros of multivariate homogeneous polynomials over finite fields

Sudhir R. Ghorpade

Indian Institute of Technology Bombay, India

It is elementary and well known that a nonzero polynomial in one variable of degree d with coefficients in a field F has at most d zeros in F. It is meaningful to ask similar questions for systems of several polynomials in several variables of a fixed degree, provided the base field F is finite. These questions become particularly interesting and challenging when one restricts to polynomials that are homogeneous, and considers zeros (other than the origin) that are non-proportional to each other. More precisely, we consider the following question:

Given a system of a fixed number of linearly independent homogeneous polynomial equations of a fixed degree with coefficients in a fixed finite field F, what is the maximum number of common zeros they can have in the corresponding protective space over F?

The case of a single homogeneous polynomial (or in geometric terms, a projective hypersurface) corresponds to a classical inequality proved by Serre in 1989. For the general case, an elaborate conjecture was made by Tsfasman and Boguslavsky, which was open for almost two decades. Recently significant progress in this direction has been made, and it is shown that while the Tsfasman-Boguslavsky Conjecture is true in certain cases, it can be false in general. Some new conjectures have also been proposed. We will give a motivated outline of these developments. If there is time and interest, connections to coding theory or to the problem of counting points of sections of Veronese varieties by linear subvarieties of a fixed dimension will also be outlined. *Co-authors:*

This talk is mainly based on joint works with Mrinmoy Datta and with Peter Beelen and Mrinmoy Datta.

Contribuited Lectures

Contribuited Lectures

Oscillation and monotonicity of the period function in piecewise linear systems

Alex Carlucci Rezende

Universidade Federal de São Carlos, Brazil

In this presentation, we investigate the global behavior of the period map for continuous piecewise linear systems formed by two distinct linear regions separated by a straight line, specifically focusing on systems that feature a period annulus at infinity. We analyze the qualitative properties of the period function across different configurations: in the center-center case, where both subsystems possess a center, we prove that the period map exhibits at most one oscillation; conversely, in the focus-focus case, we demonstrate that the period map is entirely non-oscillatory. By establishing the specific conditions under which the period function is monotonically increasing, decreasing, or constant, we provide a comprehensive characterization of the system's temporal evolution, offering new insights into the bifurcation and stability of piecewise smooth dynamical systems. *Co-authors:*

Mirianne A. S. Santos and Joan Torregrosa

Synchronization in coupled network systems: a survey

Antonio Melo

Universidade Estadual de Goiás, Brazil

The complex coordinated behavior of oscillatory components is linked to the function of many natural and technological network systems [6]. For instance, distinctive network-wide patterns of synchrony [4, 7, 5] determine the coordinated motion of orbiting particle systems [10], regulate the active power flow in electrical grids [2], predict global climate change phenomena [9], and enable numerous cognitive functions in the brain [3]. Since this rich repertoire of patterns emerges from the properties of the underlying interaction network [8], controlling the collective configuration of interdependent units holds tremendous potential across science and engineering.

Synchrony is often a consequence of symmetry, but it can occur generically in networks for other reasons, notably the existence of a balanced coloring. In this survey, we review the framework proposed by Golubitsky, Stewart and coworkers [4, 7, 5] for analyzing synchrony in networks, its main results and practical implementations based on Aldis [1].

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B-Fredholm theory in general Banach algebras

Ronalda Benjamin

University of Johannesburg

In this talk we will present some recent results and questions involving classes of elements (and the spectra derived from them) that are studied in B-Fredholm theory in general Banach algebras. *Co-authors:* Jamiu Aliyu (University of Manitoba)

Tail Extrapolation in Survival Analysis under Right Censoring: An Extended Generalized Pareto-Type Approach

Eduardo Janotti Cavalcante

Universidade de São Paulo, Brazil

This work develops a survival modeling framework based on an Extended Generalized Pareto–type construction, integrating censoring-aware inference with an explicit extreme-value structure for tail extrapolation. The proposed approach represents survival distributions as structured deviations from a generalized Pareto baseline through a flexible distributional transformation, al- lowing multiple levels of modeling complexity within a unified formulation.

The methodology accommodates right-censored data and considers alternative strategies for modeling deviations from the baseline distribution. Estimation is performed through an iterative procedure combining likelihood-based fitting of the baseline component with data-adaptive updating of the transformation mechanism. A real data application on bladder cancer recurrence illustrates the proposed framework. The resulting models provide accurate agreement with the Kaplan–Meier estimator within the observed follow-up period while yielding smooth extrapolations beyond it. Despite similar fits in the data-supported region, noticeable differences emerge in tail extrapolation, leading to substan- tially different long-term survival behavior. These findings highlight the intrinsic difficulty of identifying extreme survival characteristics from censored data and emphasize the importance of balancing flexibility and stability when performing extrapolation beyond the observation window. The proposed framework offers a coherent approach for survival analysis with censoring while drawing attention to the sensitivity of long-term predictions to modeling assumptions. *Co-authors:* Eduardo Janotti Cavalcante, Lígia Carla Pinto Henriques, Jorge Rodrigues and Antonio Carlos Pedroso de Lima

Thematic Sessions

Thematic Sessions

Session 1 - Recent Developments on Integrable Systems and Soliton Models

Organizers: Priscila Leal da Silva (UFSCar, Brazil), Igor Freire (UFSCar, Brazil), Zhijun Qiao (UTRGV, USA).

The initial value problem of the KP hierarchy

Enrique Reyes

USACH, Chile

I present a rigorous solution to the initial value problem of the KP hierarchy by means of a factorization result of infinite-dimensional Frölicher Lie groups. I also discuss how this result can be "lifted" to a KP hierarchy posed on spaces of true, not formal, pseudo-differential operators. *Co-authors:* This work is part of a joint research project with Jean-Pierre Magnot and Vladimir Roubtsov.

Instability of the peaked traveling wave in a local model for shallow water waves

Fabio Natali

UEM, Brazil

The traveling wave with the peaked profile is usually considered as a limit in the family of traveling waves with the smooth profiles. We study the linear and nonlinear stability of the peaked traveling wave by using a local model for shallow water waves, which is an extended version of the Hunter–Saxton equation. The evolution problem is well-defined in the function space $H^1_{\rm per} \cap W^{1,\infty}$, where we derive the linearized equations of motion and study the nonlinear evolution of co-periodic perturbations to the peaked periodic wave by using methods of characteristics. Within the linearized equations, we prove the spectral instability of the peaked traveling wave from the spectrum of the linearized operator in a Hilbert space, which completely covers the closed vertical strip with a specific half-width. Within the nonlinear equations, we prove the nonlinear instability of the peaked traveling wave by showing that the gradient of perturbations grow at the wave peak. By using numerical approximations of the smooth traveling waves and the spectrum of their associated linearized operator, we show that the spectral instability of the peaked traveling wave cannot be obtained as a limit in the family of the spectrally stable smooth traveling waves. *Co-authors:* Joint work with D. E. Pelinovsky and S. Wang (McMaster University).

Cauchy Problems Describing Pseudospherical Surfaces

Igor Leite Freire

UFSCar, Brazil

It is well known that solutions of certain integrable equations can define abstract surfaces with negative and constant Gaussian curvature, commonly referred to as pseudospherical surfaces. Many of these equations are viewed as evolution equations and have been extensively studied, particularly regarding the existence and uniqueness of solutions. In this talk, we will explore the connections between Cauchy problems and pseudospherical surfaces, with a particular focus on the Camassa–Holm and Degasperis–Procesi equations.

The hidden symmetries of Yang-Mills theory in (3 + 1)-dimensions

Luiz Agostinho Ferreira

USP, Brazil

We show that classical, non-supersymmetric, Yang–Mills theories coupled to spin-1/2 and spin-0 matter fields, in $(3 + 1)$-dimensional Minkowski space-time, possess an exact integrability structure with an infinite number of conserved charges in involution. Such an integrability lives on the space of non-abelian electric and magnetic charges, and is based

on flat connections in generalized loop spaces, presenting an R-matrix and Sklyanin relation. We present two novel symmetries of Yang–Mills theories. The first one are global transformations generated by the infinity of conserved charges under the Poisson brackets. The gauge and matter fields, as well as Wilson lines and fluxes, have interesting transformation laws under such a global symmetry. The second one corresponds to symmetries of the integral Yang–Mills equations, which lead to the conserved charges. They generate an infinite dimensional group, where the elements are holonomies of connections on the loop space. The conserved charges are gauge invariant, and so in the case of QCD they are color singlets, and perhaps are not confined. Therefore, the hadrons may carry such charges. Our results open up the way for the construction of non-perturbative methods for Yang–Mills theories.

On the well-posedness of the initial value problem for the MMT model

Mahendra Prasad Panthee

Unicamp, Brazil.

This work investigates the initial value problem (IVP) for the two-parameter family of dispersive wave equations known as the Majda–McLaughlin–Tabak (MMT) model, which arises in the weak turbulence theory of random waves. The MMT model can be viewed as a derivative nonlinear Schrödinger (dNLS) equation where both the nonlinearity and dispersion involve nonlocal fractional derivatives. The purpose of this study is twofold: first, to establish a sharp well-posedness theory for the MMT model; and second, to identify the critical threshold for the derivative in the nonlinearity relative to the dispersive order required to ensure well-posedness. As a by-product, we establish sharp well-posedness for non-local fractional dNLS equations; notably, our results resolve the regularity endpoint left open in the literature.

Explicit solutions for a Novikov equation

Priscila Leal da Silva

UFSCar, Brazil

In this talk, we consider a Novikov equation and present explicit traveling wave solutions. By exploiting its conservation laws and symmetry properties, we employ a collage method to construct two types of solutions: a conservative classical solution and a non-conservative blow-up solution. Moreover, we derive and explicitly present the finite-dimensional dynamical system governing the interaction of these solutions.

Lax Algebraic Representation for an Integrable Hierarchy

Shuxia Li

UTRGV, USA

Using the functional gradient approach of eigenvalues, this talk presents a pair of Lenard's operators for the Levi's vector fields and establishes commutator representations for hierarchies of Levi's equations. The relationship between potential and stationary Levi's system is discussed in the end.

Differential Calculus on the ring of generalized Colombeau numbers and results in ordinary differential equations

Wagner Cortes

UFRGS, Brazil

The theory of Colombeau generalized functions appears in the 1980s, where the main goal was to define a product on the distribution space. Colombeau constructed differential algebras $G(\Omega)$, $\Omega \subseteq \mathbb{R}^n$, containing the space of smooth functions defined on Ω as a subalgebra and the space of distributions on Ω as a subspace; that is, it was constructed an associative and commutative differential algebra containing the space of distributions and holding the Leibniz rule for differential products of two distributions. Until now, Colombeau algebras are the only known differential algebras having all these properties mentioned before. In this talk, we introduce a proposal of differential calculus and study some correspondence with ordinary calculus in Colombeau algebras. Moreover, we study the IVP problem of ordinary differential equations in Colombeau algebras.

Peakon and Beyond I: Scalar Form

Zhijun Qiao

UTRGV, USA

In this talk, I will introduce some integrable scalar models which possess peaked solitons (peakons), including the well-known Camassa–Holm (CH), the Degasperis–Procesi (DP), and other new peakon equations developed in recent years. I will take the CH case as a typical example to explain the details and show that the Camassa–Holm (CH) spectral problem yields two different integrable hierarchies of nonlinear evolution equations. In particular, the CH peakon equation is able to be extended to the DP, the b-family, the

FORQ, the Novikov, the modified CH (MoCH), and other higher order models with peakons or pseudo-peakons. Some open problems will also be addressed for discussion in the end. *Co-authors:* Some work is joint with Dr. Baoqiang Xia and Dr. Enrique Reyes.

Session 2 - Nonlinear Partial Differential Equations and Regularity Theory

Organizers: Jiazheng Zhou (UNB, Brazil), Jefferson Abrantes Santos (UFCG, Brazil), Zhizhang Wang (Fudan University, China)

Inverse Hessian curvature flow in Minkowski space

Zhizhang Wang

Fudan University, China

In this talk, we will discuss the co-compact and non co-compact entire spacelike hypersurfaces for inverse Hessian curvature flow in Minkowski space. We obtain the existence, convergence, and some applications of this flow. *Co-authors:* Dake Li and Shiqi Yin.

Lipschitz regularity estimates of almost-minimizers for Alt–Caffarelli functionals with non-standard growth

João Vitor da Silva

Universidade Estadual de Campinas, Brazil

We establish that almost-minimizers, namely, functions satisfying an appropriate variational inequality, of Alt–Caffarelli-type functionals with non-standard growth enjoy optimal Lipschitz continuity on compact subsets. Moreover, we derive universal gradient bounds for nonnegative almost-minimizers in the interior of the non-coincidence set. Our results extend recent advances in the regularity theory of weakly coupled vectorial almost-minimizers for the p-Laplacian, as developed by Bayrami et al., as well as the scalar

framework investigated by da Silva et al., Dipierro et al., and Pellegrino–Teixeira. In particular, we introduce new techniques applicable to a broad class of nonlinear one- and two-phase free boundary problems with non-standard growth. *Co-authors:* Pedro Pontes (Jilin University, China) and Minbo Yang (Zhejiang Normal University, China)

About positive solutions to degenerated logistic quasilinear-Schrödinger and Carrier problems

Carlos Alberto Pereira dos Santos

University of Brasília, Brazil

We are principally interested in establishing the existence of positive solutions to degenerated logistic elliptic problems both in the setting of quasilinear Schrödinger and Carrier-type operators. The main feature of this class of problems is the presence of regions where singularities and degeneracies occur.

Regularity theory of almost-minimizers for vectorial functionals of Bernoulli-type

Pedro Fellype Pontes

Jilin University, China

We provide an overview of the development of regularity theory for minimizers and almost-minimizers associated with variational functionals of Bernoulli type exhibiting both standard power-type growth and more general non-standard growth conditions. The main focus is on recent advances in vector-valued problems, where coupling effects and free boundaries introduce additional difficulties. We present Lipschitz regularity results for almost-minimizers in the Orlicz setting.

Isolated Singularities in Hartree-Type Equations

Tao Feng

Zhejiang Normal University, China

This talk studies isolated singularities of solutions to nonlocal Hartree-type equations. We consider critical Hartree equations in higher dimensions and planar equations with exponential nonlinearity. Using blow-up methods, integral estimates, and symmetry arguments, we describe the asymptotic behavior near singular points and extend classical results to nonlocal frameworks.

A Critical Neumann problem with anisotropic p-Laplacian

Gustavo Ferron Madeira

Universidade Federal de São Carlos, Brazil

We study the existence of positive solutions to a critical Neumann problem involving the anisotropic p-Laplacian in bounded domains inside convex cones. The main difficulty comes from the lack of compactness and anisotropic structure. The solution obtained is bounded, $C^{1,\alpha}$, and strictly positive in the domain. *Co-authors:* Olimpio Miyagaki and Alânnio Nóbrega.

Some aspects of regularity of solutions for certain elliptic systems

Luís Henrique de Miranda

Universidade de Brasília, Brazil

We study regularity properties of solutions to elliptic systems of Maxwell–Schrödinger type. Following Boccardo and Orsina, we investigate conditions on nonlinearities ensuring improved regularity and discuss a regularizing effect. A nonlocal version of the system is also considered. Joint work with A.P. de Castro Santana.

Rigidity for Non-Uniformly Elliptic Equations in Planar Strip Domains

Jefferson Abrantes Santos

Universidade Federal de Campina Grande, Brazil

We study smooth solutions to a non-uniformly elliptic equation in an unbounded strip domain with mixed boundary conditions. Under natural assumptions, we prove a rigidity result showing that the only possible configuration is trivial: the solution is linear and the boundary curves are parallel lines. The proof uses comparison principles and maximum principle techniques. *Co-authors:* David Jesus, Diego Moreira, and Sergio H. Monari Soares.

Interior Hessian estimates for Hessian quotient equations in dimension three

Heming Jiao

Harbin Institute of Technology, China

We establish interior Hessian estimates for Hessian quotient equations in dimension three and higher dimensions under different convexity assumptions. We also develop a doubling inequality method for smooth solutions and extend the approach to related fully nonlinear equations involving second symmetric functions. *Co-authors:* Zhenan Sui.

Regularity Estimates for a Nonhomogeneous Free Boundary Interface Problem

Mayra Soares

University of Brasília, Brazil

We study regularity properties of minimizers for a nonhomogeneous free boundary interface problem in Orlicz–Sobolev spaces. The functional includes transmission terms and nonlinear potentials with structural growth conditions. We obtain regularity results despite the lack of homogeneity and representation formulas.

On a nonvariational fourth order elliptic problem

To Fu Ma

University of Brasília, Brazil

We study a nonlinear fourth-order elliptic equation arising from a beam model introduced by Gao (1996). We discuss both variational and nonvariational formulations in higher dimensions and highlight differences between the two structures. *Co-authors:* O. H. Miyagaki and G. F. Madeira.

Positive normalized solutions to a singular elliptic equation with a L^2-supercritical nonlinearity

Jiazheng Zhou

University of Brasília, Brazil

We study positive normalized solutions for a singular elliptic equation with Dirichlet boundary conditions and L^2-supercritical nonlinearities. Using variational methods with a regularized functional, we prove existence results for small mass parameters.

Session 3 - Dynamical systems and ergodic theory

Organizers: Anish Ghosh (Tata Institute of Fundamental Research, India), Yuri Lima (USP, Brazil)

Surface dynamics and 3D geometry and topology: the horseshoe and its geometric limits

André de Carvalho

USP, Brazil

A basic construction in topology is the mapping torus: given a homeomorphism f of a space S, a new space M(f,S) is constructed by taking the product of S with the unit interval and gluing the two ends Sx0 and Sx1 by the map f. When f is a homeomorphism of a surface S, M(f,S) is a 3-manifold and Thurston proved theorems which state that if for any simple closed curve c, its f-iterates are never isotopic to c, then M(f,S) admits a hyperbolic metric (i.e., a complete metric with constant sectional curvature equal to -1) of finite volume. When f is a homeomorphism of the disk D with many periodic orbits — such as the Smale horseshoe — we can consider the mapping tori M(f,D-P), where P is an f-periodic orbit. Topologically, M(f,D-P) is simply a solid torus minus the knot obtained following the orbit P under the suspension flow. We will discuss a family of hyperbolic manifolds M(f,D-P), where f is the horseshoe and P are horseshoe periodic orbits, and show how understanding the dynamics of the horseshoe helps clarify a mysterious mismatch between convergence of disk homeomorphisms in the uniform topology and convergence of geometric 3-manifolds in the Gromov-Hausdorff (geometric)topology.

Sphere-filling Curves: from Cannon-Thurston Construction to Anosov-like Actions

Anindya Chanda

USP, Brazil

In their seminal work Group Invariant Peano Curves, Cannon and Thurston constructed a remarkable example of a space-filling curve on the 2-sphere, where the sphere arises as the Gromov boundary of a hyperbolic 3-manifold. The image of this curve — homeomorphic to the circle S^1 — is the boundary at infinity of a hyperbolic plane embedded in hyperbolic 3-space. This groundbreaking construction opened up several new directions of research, one of which is the study of quasigeodesic Anosov flows.

Building on this foundation, Fenley and Frankel extended the sphere-filling curve construction to more general dynamical and geometric settings, particularly in the context of quasigeodesic and Anosov flows. In this talk, we explore further generalization of this construction using a recent and powerful framework: the notion of Anosov-like group actions. This extension establishes a conceptual bridge between two emerging ideas in geometry and dynamics — namely, Zippers and Anosov-like actions — potentially leading to new insights in the structure of group actions on bi-foliated planes and construction of universal circles.

Euler characteristics of SL(2,Z)-orbit graphs of origamis of low genera

Carlos Matheus

CNRS and École Polytechnique, France

The SL(2,Z)-orbit graph of an origami O is the graph whose edges are represented by the actions of the two usual parabolic generators of SL(2,Z) and their inverses on the elements of the SL(2,Z)-orbit of O. In this talk, we discuss a joint work with Luke Jeffreys concerning the growth of the Euler characteristics of these graphs when the origami belongs to H(2), H(1,1) or the Prym loci of H(4) and H(6). For this sake, we bound the number of small faces via three distinct arguments depending on the nature of the associated Veech group element: the hyperbolic case is dealt with by the Arnoux-Yoccoz theorem, the elliptic case is handled by the relation with orbifold points in Hilbert modular surfaces, and the parabolic case is treated via the counting (a la Bombieri-Pila and Browning-Gorodnik) of integral points on ellipsoids.

Mapping Class Group invariant metrics on the Marked Moduli Space

Chaitanya Tappu

USP, Brazil

We introduce the moduli space of marked, complete, Nielsen-convex hyperbolic structures on a surface of negative (but not necessarily finite) Euler characteristic, emphasising the case in which the surface is of infinite type. The (big) mapping class group of the surface acts on this marked moduli space by change of marking. The marked moduli space reduces to the Teichmüller space in case the surface is of finite type, but it is quite distinct from the Teichmüller space in case the surface is of infinite type. The topology of the marked moduli space has many descriptions, each reminiscent of the Teichmüller space of surfaces of finite type. The (big) mapping class group acts continuously on the marked moduli space. We explore the question of whether the marked moduli space admits metrics which are invariant under this action. In ongoing work with Assaf Bar-Natan, we show that for a large class of infinite type surfaces, there is no mapping class group invariant metric on the marked moduli space.

Margulis-like measures on expanding foliations: construction and rigidity

Fan Yang

Wake Forest University, USA

Given a diffeomorphism preserving a one-dimensional expanding foliation $\mathcal{F}$ with homogeneous exponential growth, we construct a family of reference measures on each leaf of the foliation with controlled Jacobian and a Gibbs property. We then prove that for any measure of maximal u-entropy, its conditional measures on each leaf must be equivalent to the reference measures. When the measure of maximal u-entropy is a Gibbs $\mathcal{F}$-state (i.e., when the reference measures are equivalent to the leafwise Lebesgue measure), we prove that the log-determinant of f must be cohomologous to a constant. We will discuss several applications, including the strong and center foliations of Anosov diffeomorphisms, factor over Anosov diffeomorphisms, and perturbations of the time-one map of geodesic flows on surfaces with negative curvature. *Co-authors:* J. Buzzi, Y. Shi, and J. Yang.

Conjugacy of affine extensions of interval exchange transformations

Rodolfo Gutiérrez-Romo

Universidad de Chile, Chile

In 1932, Denjoy proved that any circle homeomorphism with an irrational rotation number is semiconjugate to an irrational rotation. Moreover, if the homeomorphism is sufficiently regular, then the semiconjugacy can be promoted to a conjugacy.

A natural generalization of a circle rotation is an interval exchange transformation (IET), that is, a self-map of the unit interval exchanging subintervals without overlaps. Continuing the analogy, we can replace the circle homeomorphism by a generalized interval exchange transformation (GIET), that is, a bijection of the unit interval that is piecewise continuous and increasing. The first part of Denjoy's theorem still holds: Yoccoz showed that any GIET is semiconjugate to an IET, provided it has an "irrational rotation number". Nevertheless, regularity alone is not enough to guarantee a conjugacy: there are known examples where the GIET is an affine interval exchange transformation (AIET), that is, piecewise affine, but the semiconjugacy is strict.

A landmark result in this direction was obtained by Marmi, Moussa, and Yoccoz in 2010, showing that for almost every IET T, we can construct an AIET that is strictly semiconjugate to T. The slopes of the AIET that they build satisfy a specific growth condition.

In work in progress with Carlos Matheus, Vicente Maturana-Gálvez, and Pascal Hubert, we show that this growth condition can be relaxed, yielding a much larger class of AIETs strictly semiconjugate to IETs.

Theta simplicity of Lyapunov exponents for the diagonal flow on moduli spaces of flat surfaces

Vaibhav Gadre

University of Glasgow, Scotland

Foundational work in the 80s (Thurston, Masur, Veech) on interval exchanges and translation flows gave rise to Teichmüller dynamics, a study of certain non-hyperbolic systems using hyperbolic features of its renormalisation flow (the diagonal flow for SL(2,R) action). Related Lyapunov exponents play a key role (for e.g in deviation of ergodic averages). These exponents are simple for moduli spaces of translation surfaces, a major milestone conjectured by Kontsevich–Zorich and proved by Avila–Viana in 2007.

In this talk, we will sketch our recent work (with Bell–Delecroix–G–Gutierrez-Romo–Schleimer) proving simplicity for half-translation surfaces. The moduli spaces contain many special algebraic loci arising as SL(2,R) orbit closures; these are Margulis, Ratner type theorems in this context proved by Eskin–Mirzakhani. Over these loci, the spectrum need not be simple. We will sketch ongoing work (with Arana-Herera, DeWitt, Eskin, Gutierrez-Romo, Lima, Matheus, Rafi and Schleimer) proving the full theta-simplicity, namely that the spectrum is as simple as dictated by the algebraic monodromy of the locus.

Session 4 -Finite Fields and Applications

Organizers: Cícero Carvalho (Universidade Federal de Uberlândia, Brazil), Sudhir Ghorpade (Indian Institute of Technology Bombay, India), Luciane Quoos (Universidade Federal do Rio de Janeiro, Brazil)

Curves on Frobenius nonclassical loci of hypersurfaces

Nazar Arakelian

Universidade de São Paulo, Brazil

Let $S \subset \mathbb{P}^n$ be an absolutely irreducible projective hypersurface defined over a finite field $\mathbb{F}_q$, equipped with the $\mathbb{F}_q$-Frobenius map Φ_q. In this work we investigate irreducible curves $\mathcal{X} \subset \mathcal{S}_{\Phi_q}$, where $\mathcal{S}_{\Phi_q}$ is the $\mathbb{F}_q$-Frobenius nonclassical locus of $\mathcal{S}$. In particular, we show that every curve $\mathcal{X} \subset \mathcal{S}_{\Phi_q}$ such that the restriction of the Gauss map of $\mathcal{S}$ to $\mathcal{X}$ is inseparable is $\mathbb{F}_q$-Frobenius nonclassical. This provides a way to construct new Frobenius nonclassical curves, which are curves that tend to have many $\mathbb{F}_q$-rational points. We also prove that a certain type of Frobenius nonclassical hypersurfaces $\mathcal{S}$ defined by separated variables are such that their Gauss maps restricted to any curve contained in $\mathcal{S}$ is inseparable. Finally, in parallel with the plane curve cases, we show that if the strict Gauss map Γ of a $\mathbb{F}_q$-Frobenius nonclassical hypersurface $\mathcal{S}$ is given by p powers, then Γ is purely inseparable.
Co-authors: Pietro Speziali

Schubert Varieties and Linear Codes

Sudhir R. Ghorpade

Indian Institute of Technology Bombay, Mumbai, India

A Grassmannian may be defined as a collection of subspaces of a fixed dimension of a finite dimensional vector space over a field. It embeds naturally into a large projective space, via the so-called Plucker embedding, and as such it can be viewed as a projective algebraic variety. Any Grassmannian has a distinguished class of closed subvarieties known as Schubert varieties. When the base field is finite, such a Schubert variety (together with its natural nondegenerate embedding in a subspace of the Plucker projective space) give rise to an interesting class of linear codes. These codes have been of considerable interest in the past few decades. In this talk, we shall outline several results and open problems concerning them.

A general framework of non-Reed-Solomon MDS Codes

Lingfei Jin

Fudan University, Shanghai, China

MDS codes have garnered significant attention due to their wide applications in practice. To date, most known MDS codes are equivalent to Reed-Solomon codes. The construction of non-Reed-Solomon (non-RS) type MDS codes has emerged as an intriguing and important problem in both coding theory and finite geometry. In this talk, we introduce a general framework of constructing non-RS MDS codes.

A survey on recent results on the applications of group algebras to Coding Theory

César Polcino

Universidade de São Paulo, Brazil

In this talk we aim to report on recent results obtained in the study of essential idempotents in group algebras and their relationship with Code Theory, among other applications of group algebras to Coding Theory.

A closed formula for the Geil-Matsumoto bound

Luciane Quoos

Universidade Federal do Rio de Janeiro, Brazil

The Geil-Matsumoto bound (GM bound) constrains the number of rational points on a curve over a finite field in terms of the Weierstrass semigroup of any of the points on the curve. For general numerical semigroups, the GM bound lacks a simple closed-form expression, making its computation a challenging problem. A closed formula has been obtained for the case when the semigroup is generated by two co-prime integers. In this talk, for any numerical semigroup, we provide a closed formula for the GM bound in terms of the Apéry set of a nonzero element of the semigroup. In the case where the numerical semigroup is generated by consecutive integers $n, n+1, \ldots, n+t$ with $\left\lceil \frac{n-1}{2} \right\rceil \leq t \leq n-1$, we obtain a simple closed formula for the bound. We apply these results to obtain upper bounds on the number of rational points for algebraic curves over finite fields. In some cases, the GM bound improves some well-known upper bounds on the number of rational points.

Polynomials that are free of binomials

Lucas Reis

Universidade Federal de Minas Gerais, Brazil

In recent work, we investigated variations of the Primitive Normal Basis Theorem (Lenstra–Schoof, 1987). In particular, we reduced the problem of determining the existence of primitive k-normal elements over finite fields to a purely arithmetic question, provided the base field is sufficiently large. This reduction led us to introduce and study a class of polynomials over finite fields that divide only binomials of the form $x^n - 1$. In this talk, we briefly describe this connection, present our recent results, and outline directions for future research. This talk is based on a joint work with S. Ribas and F. Brochero-Martínez.

On singular and maximal curves over finite fields

Rodrigo Salomão

Universidade Federal Fluminense, Brazil

The number of rational points on a smooth algebraic curve defined over a finite field Fq is classically bounded by the Hasse–Weil inequality. This bound extends to singular curves, as shown by Aubry and Perret, who established an analogue of the Weil bound in terms of the geometric genus of the normalization and the delta invariants of the singularities.

A singular curve over Fq is called maximal if it attains this extended bound with equality. A fundamental example of a maximal rational curve is the Ballico–Hefez curve, which has long served as the prototypical instance of this phenomenon.

In this talk, we exhibit new families of maximal singular plane curves, including explicit examples of maximal plane cubics and quartics. We further construct infinite families of maximal curves whose normalization is a hyperelliptic curve, and we investigate aspects of their geometry, with particular attention to their gonality. *Co-authors:* Renato Vidal da Silva Martins (UFMG) and Cesar Augusto Hilario Poma (PUC Lima).

Linear Codes from Simplicial Complexes: Constructions and Applications

Anuradha Sharma

Indraprastha Institute of Information Technology Delhi, India

We present several constructions of linear codes over finite fields arising from simplicial complexes that yield new parameters. We compute their fundamental parameters and Hamming weight enumerators, determine the parameters of their dual codes, and investigate their hulls, explicitly computing their dimensions.

As applications, we obtain infinite families of linear codes with desirable properties, including projective few-weight codes, minimal codes, distance-optimal and dimension-optimal codes, as well as self-orthogonal and LCD codes. We further explore applications to quantum error-correcting codes and to Massey's secret sharing schemes via the duals of minimal codes. In addition, we analyze their locality properties and derive infinite families of alphabet-optimal locally repairable codes.

The weight spectrum cardinality theory of linear codes

Minjia Shi

Anhui University, Hefei, China

In coding theory, the weight spectrum, code length, dimension, and minimum distance are recognized as the four most essential and fundamental parameters of a code. Ascertaining the upper and lower bounds on the size of a code's weight spectrum constitutes a foundational problem in this field. This report presents a concise survey of the upper and lower bounds on the size of weight spectra from three distinct perspectives. First, we investigate the bounds for several critically important families of linear codes, including cyclic codes, quasi-cyclic codes, and Reed–Muller codes. Second, we explore the bounds for codes defined over finite rings, where diverse weight metrics are taken into account, such as the Lee weight and the homogeneous weight. Third, we examine the bounds for codes under the symbol-pair metric.

Towards the classification of algebraic curves with transitive actions on Weierstrass points

Pietro Speziali

Universidade Estadual de Campinas, Brazil

Let X be a non-singular algebraic curve of genus $g > 1$ defined over an algebraically closed field of characteristic p greater than or equal to zero. Also, we assume that the full automorphism group $Aut(X)$ of X is non-trivial. We say that X is classical with respect to the canonical series W if the gap-sequence at a generic point P of X is equal to $\{1, \dots, g\}$. Otherwise, we say that X is non-classical. If $p = 0$, or if $p > 2g - 2$, any curve is classical; when the characteristic of the ground field is small when compared to g, non-classical curves may exist. A point P of X is said to be a Weierstrass point if its gap-sequence is

different from the generic one. A classical result states that X admits a finite number of Weierstrass points. Since the genus is bigger than one, $Aut(X)$ is a finite group, which must act on the set W of the Weierstrass points of X. Since $Aut(X)$ must act on W, it is natural to inquire on the possible actions of $Aut(X)$ on W; a fair question is if this action can be transitive. First, we focus on the case when X is classical. As it turns out, this latter is a rare possibility, with only few examples in the literature, and, only two infinite family of examples, namely the famous (hyperelliptic) Accola-Maclachlan curves and the so-called Kuribayashi- Komiya quartics (the latter being a recent contribution in a joint work with Sebastián Reyes-Carocca). In this talk, we focus on recent developments on this subject, mostly by providing new infinite families of curves with no transitive action on their Weierstrass points.

Session 5 - Stochastic Processes on Graphs and Networks

Organizers: Anatoli Iambartsev (USP, Brazil), Fábio Machado (USP, Brazil)

Strong Laws of Large Numbers for Random Variables Satisfying a Pairwise ρ-Mixing Condition

Artem Logachev

Sobolev Institute of Mathematics, Novosibirsk, Russia / Institute of Mathematics and Statistics, USP, São Paulo, Brasil

We introduce pairwise versions of the classical ρ- and φ-mixing coefficients and establish strong and weak laws of large numbers for identically distributed random variables under assumptions involving only pairwise dependence between distant observations. The main result provides a sufficient condition for the strong law in terms of the growth of the cumulative pairwise mixing function and an associated moment condition. Several explicit corollaries are obtained for polynomial rates of decay of the pairwise mixing coefficients. We also prove L^1 convergence and identify the limit in the strong law under summability assumptions on pairwise φ-mixing coefficients.

Passage Times for Partially Homogeneous Reflected Random Walks on the Quadrant

Conrado Costa

Universidade de São Paulo, São Paulo, Brazil

The aim of this talk is to present the study of non-homogeneous random walks confined to the positive quadrant. As a variation on this theme, we consider a partially homogeneous transition mechanism with four types of transition laws: one for the interior, one for the horizontal boundary, one for the vertical boundary, and one for the origin. Under mild assumptions, in the critical case where the interior drift is zero, we obtain a recurrence/transience classification and prove power-law bounds for the tails of passage times. The criteria are expressed in terms of the interior covariance matrix, the drifts associated with the boundaries, and the stationary distributions of two one-dimensional Markov chains naturally associated with each of the two boundaries.

Coverage properties for the frog model on complete graphs

Gustavo Oshiro de Carvalho

Universidade de Campinas, Campinas, Brazil

We consider a system of interacting random walks known as the frog model on complete graphs. Initially, an active particle is placed at one vertex of the n-complete graph K_n, as well as one inactive particle at every other vertex. At each instant of time, each active particle may die with probability $1-p$. Every active particle performs a simple symmetric random walk on K_n until the moment it dies, activating all inactive particles it hits along its path. In this talk, we study some asymptotic properties, as n approaches infinity, of the number of visited vertices until all active particles have died. In particular, we study conditions for the existence of a giant component, as well as conditions for covering the graph.

The Frog Model on $\mathbb{Z}$ with discrete Weibull lifetimes and random parameter p

José Hermenegildo Ramírez

Universidade de São Paulo, São Paulo, Brazil

We study the frog model on $\mathbb{Z}$ with particle-wise random geometric lifetimes: each particle has a survival parameter $\pi \in (0,1)$ sampled i.i.d., whose density near 1 satisfies $f_\pi(u) \sim (1-u)^{\beta-1} L\big((1-u)^{-1}\big)$ with $\beta > 0$, and L slowly varying. This strictly extends the Beta(α, β) case. Let η denote the common law of the i.i.d. initial number of particles

$\{\eta_x\}_{x\in\mathbb{Z}}$. Using a percolation comparison and sharp one-particle displacement tails, we obtain a universal threshold at $\beta = 1/2$. If $\beta > 1/2$ and $E(\eta) < \infty$, extinction occurs almost surely. If $\beta < 1/2$ and $\mathbb{P}(\eta = 0) < 1$, survival has positive probability. At the boundary $\beta = 1/2$ we give sharp criteria: extinction if $E(\eta) < \infty$ and $8 \limsup_{n\to\infty} L(n^2) < 1/E(\eta)$; survival if $\mathbb{P}(\eta = 0) < 1$ and $\sqrt{2} \liminf_{n\to\infty} L(n^2) > 1/E(\eta)$. These results recover the Carvalho–Machado threshold for Beta laws and show that only the exponent β governs the phase transition, while L impacts the critical regime.

Refinements of the Asymptotic Shape Theorem and Coexistence of Species on Random Geometric Graphs

Lucas Lima

Universidade de São Paulo, São Carlos, Brazil

This talk presents recent refinements of the asymptotic shape theorem for first-passage percolation on random geometric graphs (RGGs), including quantitative shape estimates and rates of convergence to the asymptotic shape. These results rely on moderate deviation estimates for passage times and provide a finer understanding of the growth process beyond the classical shape theorem. As an application, we study the coexistence of two competing species on RGGs in continuous time. The species spread by occupying vacant sites according to Richardson's growth model while competing for occupied sites through the dynamics of the voter model. We prove that coexistence occurs with strictly positive annealed probability. The proof combines the quantitative first-passage percolation estimates with random walk techniques to control the competition in suitable spatial regions.

The Truncation Question in Percolation of Words

Pablo Gomes

Universidade de São Paulo, São Paulo, Brazil

In this talk, we investigate the truncation question in the context of percolation of words. Consider the set $\mathbb{Z}^d$, where each vertex is independently assigned the letter 1 with probability p, and the letter 0 with probability $1 - p$. Long-range edges of length n are declared open with probability p_n. The goal is to analyze the existence of a sufficiently large K such that, with positive probability, all words are seen from the origin, even if the edges of length larger than K are removed from the lattice. *Co-authors:* Based on joint work with Otavio Lima and Roger W. C. Silva.

Hierarchical Clustering Algorithms on Point

Saye Khaniha

Universidade de São Paulo, São Paulo, Brazil

Hierarchical clustering is traditionally designed for finite datasets. In this talk, I will discuss how such a hierarchy can be constructed when the data consist of a countably infinite collection of points in Euclidean space.

We introduce the Clustroid Hierarchical Nearest Neighbor (CHN^2) algorithm. At the first level, every point is linked to its nearest neighbor. Each resulting cluster contains a mutual nearest-neighbor pair, which serves as its representative, or clustroid pair. At the following levels, clusters are linked through these representatives, producing progressively larger groups while retaining only a small amount of information from each cluster.

We first study the algorithm on a homogeneous Poisson point process, which provides a natural baseline model with no intrinsic spatial aggregation. We prove that the construction is well defined at every level: almost surely, all clusters formed at any finite stage remain finite, and we obtain bounds on their mean size.

As the number of levels tends to infinity, the hierarchy stabilizes locally and gives rise to a unimodular random forest. Its connected components are infinite and one-ended. Intuitively, although a component may branch in many directions when traced toward its descendants, it has a unique direction toward higher levels of the hierarchy. This induces a natural genealogical ordering within each component and gives the limiting forest a tree-like, phylogenetic interpretation. *Co-authors:* This is joint work with François Baccelli.

Cutoff of the simple exclusion process with inhomogeneous conductances

Shangjie Yang

Universidade Federal Fluminense Federal, Niteroi, Brazil

We study the mixing time of the simple exclusion process on a finite line segment with varying edge conductances. In this model, the contents of two adjacent sites are swapped at rates determined by these conductances. Under the assumption that the resistances (the inverse of the conductances) grow linearly, along with certain additional conditions, we prove that the process exhibits the cutoff phenomenon. Specifically, we demonstrate that at a critical time, the total variation distance to equilibrium drops abruptly from 1 to 0.

Session 6 - Mathematical and Computational Modeling

Organizers: Yulia Petrova (USP, Brazil), Maicon Ribeiro Correa (USP, Brazil), Lucas Franceschini (USP, Brazil), Joao G. C. Steinstraesser (USP, Brazil)

An Inverse Problem for Source Identification in a Coupled Acoustic Fluid–Euler–Bernoulli Beam Model

Alexandre Kawano

Poli-USP, University of São Paulo, Brazil

We consider an inverse source problem arising in a coupled fluid–structure interaction model, where a compressible fluid occupies a rectangular domain whose lower boundary is an elastic Euler-Bernoulli beam. The coupled system is driven by two unknown spatial source terms with prescribed time dependence, one acting in the acoustic fluid equation and the other in the beam equation. The inverse problem consists in recovering both spatial components from partial observations of the beam displacement over a finite time interval. The governing equations form a coupled wave–beam system, supplemented with suitable transmission and boundary conditions at the fluid–structure interface and on the exterior boundary. We prove a uniqueness theorem for the simultaneous identification of the two source terms from restricted boundary/structural measurements. Numerical experiments corroborate the theoretical result and illustrate the influence of the minimal observation time, as well as the stability of the reconstruction with respect to measurement noise. The analysis contributes to the mathematical theory of inverse problems for vibroacoustic systems and provides a rigorous framework for applications such as structural health monitoring and source localization.

Contact modeling with the master-master approach and applications

Alfredo Gay Neto

Poli-USP, University of São Paulo, Brazil

In computational mechanics, when addressing the interaction between bodies, one needs a mathematical representation of constraints. Physically, these are restrictions on certain degrees of freedom (or their derivatives), generally represented by constraint equations. These constraints, along with the equations of motion of the bodies, compose a system of differential and algebraic equations. There is a particular condition that portrays the condition of non-penetration of one body onto the other, called "contact constraint," which can be represented by the Karush-Kuhn-Tucker conditions. The forms of numerical solution of this type of problem is an ongoing research goal of the computational mechanics

community, so there are several numerical methods available - often sharing solution methods within an optimization framework, such as the penalty method, Lagrange multipliers, among other alternatives. A common approach to geometrically test the contact condition is called master-slave technique: one of the body's surface is discretized into contact detection points, and the other one is parameterized. Solving a unilateral projection problem, the penetration condition is tested and handled. This work will address a specific contact treatment proposal, called master-master, in which there is no distinction in the treatment of both bodies. Both contact surfaces are parameterized and a bilateral projection problem is proposed, responsible for testing the penetration condition. Discussions will be made about the nature of the solution to this problem, numerical implications, and examples of solutions in real engineering problems.

T.B.A.

Bruno Souza Carmo

Poli-USP, Brazil

T.B.A.

Efficient multiscale preconditioners for subsurface flow in porous media

Fabrício Simeoni de Souza

ICMC-USP, Universidade de São Paulo, Brazil

Advances in multicore distributed computing have fueled the demand for high-resolution simulations of porous media and reservoir flows, emphasizing the need for scalable, high-performance solvers. In this talk, we will introduce new preconditioners for conjugate gradient (CG) methods based on two-level domain decomposition methods. The developed preconditioners are based on the algebraic formulation of the Multiscale Robin Coupled Method (MRCM), enhanced with smoothing operators, yielding a symmetric positive-definite preconditioner well-suited for pressure systems discretized using the two-point flux approximation. Implemented in a parallel framework, the approach computes multiscale basis functions concurrently across subdomains. Benchmark tests on heterogeneous porous media demonstrate strong robustness and scalability, showing competitive performance against established techniques such as Algebraic Multigrid.

Topology Optimization for Additive Manufacturing: Design and Fabrication

Geovane Haveroth

ICMC-USP, Universidade de São Paulo, Brazil

Topology Optimization (TO) has become one of the leading tools for the design of lightweight and efficient mechanical structures. However, the high geometric complexity of the resulting designs often makes their fabrication through conventional manufacturing methods impractical. This is precisely where Additive Manufacturing (AM) becomes essential. As a core technology of Industry 4.0, AM, particularly in metal and polymer processing, has revolutionized the way components are produced. Despite the apparent synergy between TO and AM, integrating these two fields requires a careful approach. Although additive processes are highly versatile, they impose important constraints that may compromise the quality of the final part or even render the manufacturing of optimized structures unfeasible.

In this talk, we will discuss the fundamentals of metal AM, the main practical challenges encountered in the field, and recent strategies proposed in the literature to incorporate manufacturing constraints into TO models. The goal is to demonstrate how design and fabrication stages can be integrated to achieve solutions that are both innovative and manufacturable.

On the application of goal-oriented error estimation to Mixed Finite Element methods

Giovanni Taraschi

UNICAMP, Brazil

One key ingredient to develop computationally efficient finite element simulations is the use of a posteriori error estimators to guide the mesh refinement process. Most classical strategies estimate the error according to the so-called energy norm, which is induced by the variational form of the PDE problem. An alternative approach is to estimate the error according to a functional that represents the quantity of interest of the simulation. This latter strategy, known as goal-oriented error estimation, has been successfully applied to the standard H1-conforming finite element method. In this work we discuss the challenges in extending it to the more general case of Mixed Finite Element methods.

Graph-Based Permeability Upscaling in Fracture Networks

Josué Barroso

Laboratório Nacional de Computação Cientifica (LNCC), Brazil

Fluid flow in fractured rocks is strongly governed by the topology and hydraulic properties of fracture networks. Although Discrete Fracture Network models provide detailed representations of these systems, their direct use in reservoir-scale simulations is often computationally prohibitive. Upscaling methods are therefore required to transfer fracture-scale information to coarser models, but classical approaches such as Oda's method may be sensitive to fracture density, anisotropy, and connectivity. We propose a graph-based strategy to estimate the equivalent permeability of fracture network. In this formulation, fracture intersections are represented as graph nodes, while fracture segments connecting them are treated as edges weighted by hydraulic conductance, computed from properties such as aperture and permeability. This representation allows the fracture network to be interpreted analogously to an electrical circuit. The equivalent permeability is obtained by progressively reducing the graph through circuit-based transformations, including series, parallel, and star–mesh operations. These reductions preserve the global pressure–flow response of the original network until a single equivalent conductance is obtained and converted into an equivalent permeability. The proposed approach provides a computationally efficient alternative for fracture-network upscaling, enabling rapid evaluation of multiple scenarios without explicitly meshing or solving flow equations on the full DFN.

New paradigms for turbulent flow modeling: stochastic mapping and resolvent analysis

Lıvia Souza Freire

ICMC-USP, University of São Paulo, Brazil

The mathematical description of turbulent fluid flows remains one of the most enduring challenges in non-linear continuum mechanics, owing to its multi-scale and chaotic nature, in addition to the analytical intractability of the Navier-Stokes equations. This talk details two distinct mathematical tools designed to model different aspects of these highly nonlinear dynamics. The first approach uses the One-Dimensional Turbulence (ODT) framework, a deterministic-stochastic formulation that maps three-dimensional spatial complexity onto a one-dimensional line while preserving the multi-scale energy cascade. By combining transport equations with discrete, measure-preserving stochastic eddy transformations, this technique captures complex fluid mixing within a reduced space. The second approach establishes an operator-theoretic framework through Resolvent Analysis. By recasting the governing equations as a linear input-output system, the nonlinear terms are modeled as external forcing acting on the linearized Navier–Stokes operator. This formulation enables the extraction, via singular value decomposition, of optimal response modes and amplification mechanisms that are strongly associated with the most energetic coherent structures in the flow. Together, these frameworks demonstrate how distinct mathematical abstractions can provide complementary insight into turbulent dynamics across scales.

An all-at-once formulation for the electrical resistivity problem

Nelson Kuhl

IME-USP, University of São Paulo, Brazil

An all-at-once formulation [2, 3] for a 2D Electrical Resistivity Tomography (ERT) problem is proposed. Imposing the Complete Electrode Model [1] on the upper surface of the domain and absorbing boundary at the bottom and on the lateral parts, an abstract problem is presented in the context of Banach spaces. Using weak topologies and compactness arguments, existence, stability, and convergence of regularized solutions are proved. Some numerical tests are performed to assess the viability of this formulation.

[1] E. Somersalo, M. Cheney, D. Isaacson, Existence and uniqueness for electrode models for electric current computed tomography, SIAM J. Appl. Math., 52(4) (1992), 1023 -1040.
[2] B. Kaltenbacher, Minimization based formulations of inverse problems and their regularization, SIAM Journal on Optimization, 28(1) (2018), 620 -645.
[3] J. Dıaz-Avalos, N. Mugayar Kuhl, Regularizations for an all-at-once formulation of the electrical impedance tomography problem, Journal of Inverse Ill-Posed Problems, 34(1) (2025), 87 -120.

Wave propagation modelling using physics-informed neural networks

Pavel Petrov

IMPA - Brazil

Recently physics-informed neural networks (PINNs) have gained prominence as a tool for solving differential equations describing a broad range of physical phenomena, including propagation of waves in various areas of science and engineering. Several attempts have been made to adapt this technology to the solution of wave equation in unbounded media typical for sound propagation in a geoacoustic waveguide. Various challenges have emerged when using PINNs in this context. In particular, it has been observed that neural networks tend to violate causality and to converge to trivial (identically zero) solutions of the wave equation. Another difficulty consists in enforcing initial conditions. Finally, balancing various loss terms, e.g., the terms corresponding to the equation and to boundary conditions, in the course of the neural network training turns out to be another complication. In this study a PINN architecture and an approach to the training that allow to deal with the aforementioned issues are discussed. Firstly, the so-called absorbing boundary conditions are imposed in order to regularize the training process and avoid local minima of the loss associated with trivial solutions. Secondly, neuro-tangent kernel technique is applied in order to accomplish dynamic loss balancing in such a way that all its components come into play. By construction, our neural network also respects zero Cauchy data for the wave equation (initial conditions). Finally, adaptive sampling of the computational domain is used in order to ensure that computational resources are focused on its parts where the wavefield is actually localized in a given moment of time. Several numerical experiments for geoacoustic waveguides of various complexity are presented, including a deep-water

waveguide with the bottom reproducing the so-called Marmousi model. It is shown that our approach allows to train a PINN that demonstrates wavefield simulation accuracy comparable to the traditional numerical methods using much less computational resources than other state-of-the art PINN-based methods. Possible extensions and generalizations of our approach are discussed. *Co-authors:* Márcio Marques, Leonardo Mendonça, Arthur Bizzi, Leonardo Moreira, Christian de Oliveira, Deborah Oliveira, Vitor Balestro, Lucas Fernandez, Daniel Yukimura, Pavel Petrov, João Pereira, Tiago Novello, Lucas Nissenbaum.

Fingering phenomenon in unstable displacement in porous media

Sergey Tikhomirov

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Fingering phenomenon appears as the result of unstable displacement of miscible liq- uids in porous media with the speed determined by Darcy's law. Such model is called Peaceman model (viscous fingers) or incompressible porous medium equation (gravitational fingers). Viscous fingers phenomenon plays an important role in petroleum engineering in case of highly viscous oil or certain enhanced oil recovery methods. Laboratory and numerical experiments show the linear growth of the mixing zone, and we are interested in determining the exact speed of propagation of fingers. Knowledge of the precise value of the speed of the fingers would allow to optimize injection scheme of certain enhanced oil recovery methods (for instance polymer and surfactant-polymer flooding). The existing theoretical upper bounds for the growth rate of the mixing zone are higher than the observed speed from the numerical simulations.

We believe that one of the possible mechanisms of slowing down the fingers' growth is due to convection in the transversal direction and explain it by introducing a semi-discrete model. The model consists of a system of advection-reaction-diffusion equations on concentration, velocity and pressure in several vertical tubes (real lines) and interflow between them. In the simplest setting of two tubes, we show the structure of gravitational fingers – the profile of propagation is characterized by two consecutive traveling waves which we call a terrace. We prove the existence of such a propagating terrace for the parameters corresponding to small distances between the tubes. While for multiple tubes the solution has more complicated structure than propagating terrace, a structure similar to two-tubes model describes significant part of the solution. An important tool is introduction of so-called Transverse Flow Equilibrium (TFE) model, derived under realistic assumption that pressure gradient is mostly vertical. The TFE model is easier to simulate and in certain cases admits an exact solution. We establish rigorous relations between IPM and TFE models. *Co-authors:* Yu. Petrova, Ya. Efendiev, K. Kalinin, F. Bakharev, A. Enin, S. Matveenko, D. Pavlov, N. Rastegaev, I. Starkov.

Modeling nanoparticle-stabilized foam flow in porous media: Mathematical analysis and uncertainty quantification

Tatiana Danelon

Universidade Federal de Juiz de Fora (UFJF), Brazil

Foams have potential applications as mobility-control agents to optimize gas flooding in several subsurface processes, such as aquifer remediation, greenhouse carbon storage, and enhanced oil recovery. Experimental studies indicate that their stability and resistance can be enhanced by adding nanoparticles. In this work, we present two new mathematical models for nanoparticle-stabilized foam flow in porous media. The first assumes foam at local equilibrium and is governed by a non-strictly hyperbolic system of conservation laws, for which we provide a global analytical solution, enabling efficient sensitivity and uncertainty analyses. We also discuss the most favorable conditions for observing nanoparticle effects in laboratory experiments. The second model incorporates foam texture, nanoparticle retention, and the resulting permeability reduction. For this more complex case, we present a steady-state semi-analytical solution, used to investigate how suspended nanoparticle loss and reduced permeability influence foam flow.

Session 7 - Symposium on Contemporary Differential Geometry at USP

Organizer: Marcos M. Alexandrino (Universidade de São Paulo, Brazil)

Mean Curvature Flow for Isoparametric Submanifolds in Hyperbolic Spaces

Xiaobo Liu

Beijing Mathematical Center, China

Mean curvature flow (MCF) of isoparametric submanifolds in Euclidean spaces and spheres have been studied by Liu and Terng. They have been used to give explicit ancient solutions of MCF with complicated topological type and study rigidity of ancient solutions of MCF for hypersurfaces in spheres. In this talk, I will describe behavior of MCF of isoparametric submanifolds in hyperbolic spaces. This talk is based on a joint work with Wanxu Yang.

C^0-rigidity of the Hamiltonian diffeomorphism group of symplectic rational surfaces

Marcelo Atallah

Universidade de São Paulo, Brazil

Co-authors: A natural question bridging the celebrated Gromov–Eliashberg theorem, establishing that the symplectic diffeomorphism group is a C^0-closed subgroup of the diffeomorphism group of a symplectic manifold, and the C^0-flux conjecture is whether the identity component of the group of symplectic diffeomorphisms is C^0-closed in $Symp(M, \omega)$. Beyond surfaces and the cases in which the Torelli subgroup of $Symp(M, \omega)$ coincides with the identity component, little is known. In joint work with Cheuk Yu Mak and Wewei Wu, we show that, for all but a few positive rational surfaces, the group of Hamiltonian diffeomorphisms is the C^0-connected component of the identity in $Symp(M, \omega)$, thereby giving a positive answer in this setting. Here, "positive rational surface" essentially means a k-point blow-up of CP^2 whose symplectic form evaluates positively on the first Chern class.

Reduction Principles for Proper Actions

Leonardo Biliotti

Universit'a degli studi di Parma

In this talk, we review some fundamental aspects of proper group actions on smooth manifolds and describe the construction of the core. We demonstrate that many properties of a proper action can be understood and characterized through the corresponding action on the core. *Co-authors:* Gustavo May Custodio and Alessandro Minuzzo

Lie Theory and Cartan's Realization Problem

Ivan Struchiner

Universidade de São Paulo, Brazil

This talk focuses on the Lie theoretic objects controlling moduli problems for G-structures with connections satisfying diffeomorphism-invariant PDEs. While finite-type realizations are governed by G-structure algebroids with connections (joint with R. L. Fernandes), infinite-type problems for coframes are controlled by relative Lie algebroids, as established by Fernandes and Smilde. Finally, we report on ongoing research putting both frameworks together via relative G-structure algebroids with connections to attack general infinite-type problems.

When is a singular Finsler foliation actually Riemannian? The case of (α, β) spaces

Patrícia Marçal

Universidade de São Paulo, Brazil

Singular Riemannian foliations (SRFs) provide a unifying language for isometric group actions, Riemannian submersions, and partitions by holonomy groupoids of a metric connection, and their study has been central to submanifold and metric geometry for decades. Their natural Finslerian counterparts, singular Finsler foliations (SFFs), arise as orbits of Finsler isometric actions, fibers of Finsler submersions, and level sets of some transnormal functions. A natural question in this area, going back to a problem of Ghys, asks under which conditions a singular Finsler foliation coincides with a singular Riemannian foliation with respect to some Riemannian metric. In this talk I will discuss recent joint work with M. M. Alexandrino and B. O. Alves, where we answer this question for singular Finsler foliations of (,)-spaces, i.e. manifolds equipped with $(\alpha, beta)$-metrics. These are among the most tractable and widely used non-Riemannian Finsler metrics, with applications ranging from Zermelo navigation to wildfire-spread modeling. Time permitting, I will explain how this characterization led us to extend Molino's conjecture (closure of the leaves of an SRF remains an SRF) to singular Finsler foliations that are simultaneously SRFs, and establish equifocality of regular leaves of such foliations with respect to the Finsler metric itself. *Co-authors:*

Multiplicative sections of CA-groupoids

Clarice de Souza Ferreira Netto

Universidade de São Paulo, Brazil

A strong connection between differential geometric structures and category theory can be found in the literature, with several works spanning both areas. For example, by considering the complex of multiplicative sections of a VB-groupoid, we obtain an associated category of 2-vector spaces. In this talk, we will show that the category of 2-term ∞-Leibniz algebras is related to the complex of multiplicative sections of a twisted CA-groupoid. Furthermore, we will see how a morphism between twisted CA-groupoids allows us to construct a 2-term ∞-Leibniz algebra.

Poster Sessions

Poster Sessions

(n,1)-Stacked Central Configurations

Anderson Mauro da Silva

Universidade Federal de Pernambuco, Brazil

We present a study of planar, non-collinear (n, 1)-stacked central configurations. We show that such configurations must be circular and that, for $n \leq 7$, the only (n, 1)-stacked central configurations are those formed by a regular polygon with equal masses at its vertices and an arbitrary mass at the center of the circle.

Attractor Continuity for Semilinear Parabolic Equations on Thin Domains with Degenerating Outward Peaks

Bianca Paolini Lorenzi

Universidade de São Paulo, Brazil

In this work, we analyze the asymptotic behavior of the attractors associated with a semilinear parabolic equation subject to homogeneous Neumann boundary conditions and defined on a thin domain $R^\varepsilon \subset \mathbb{R}^{1+n}$. We assume that the thin domain exhibits a cusp, known as an outward peak, whose geometry is characterized by a nonnegative function that vanishes at a point on the boundary. Our objective is to rigorously establish the continuity of the attractors as $\varepsilon \to 0$ and to determine their rate of convergence. *Co-authors:*

Elaine Andressa Tavares de Lima - Universidade de São Paulo; Marcone Corrêa Pereira - Universidade de São Paulo.

Existence of solutions with prescribed frequency for perturbed Schrodinger-Bopp-Podolsky systems in bounded domains

Bruno Mascaro

Universidade Presbiteriana Mackenzie, Brazil

In this poster, we show that the Schrodinger-Bopp-Podolsky system with Dirichlet boundary conditions in a bounded domain possesses infinitely many solutions of prescribed frequency, for any set of (continuous) boundary conditions, provided that the Schrodinger equation is perturbed with a suitable nonlinearity. Our approach is variational, and our proof is based on a symmetric variant of the Mountain Pass theorem. *Co-authors:* Danilo Gregorin Afonso; Università San Raffaele, Roma

Beyond L^p: Nonlinear Problems with Measure Data

Carlos Eduardo Passarin Segantin

Universidade Estadual de Campinas, Brazil

Este trabalho investiga o problema de Dirichlet não linear com termo de absorção $-\Delta u + g(u) = \mu$ em Ω, $u = 0$ em $\partial\Omega$, onde $\Omega \subset \mathbb{R}^N$ é limitado com fronteira suave, g é contínua com $g(t)t \geq 0$, e μ é uma medida de Borel finita. A motivação advém de modelos físicos como a teoria de Thomas-Fermi e modelos de vórtices, nos quais surgem medidas de Dirac. Diferentemente da abordagem clássica com dados em L^p, o tratamento com medidas exige novas ferramentas analíticas. O estudo desenvolve uma estrutura baseada em espaços de Sobolev, capacidade de Sobolev, potencial Newtoniano e decomposição de Radon-Nikodym-Lebesgue. Resultados fundamentais incluem: a caracterização de soluções da equação de Poisson via potencial Newtoniano e função harmônica; a equivalência entre formulações distribucionais e no dual; e a extensão dos princípios do máximo (fraco e inverso) para medidas, utilizando a decomposição da medida em partes difusa e concentrada relativa à capacidade $W^{1,2}$. A passagem de dados integráveis para dados medida não é meramente técnica: impõe dificuldades que exigem a análise separada dos efeitos das partes difusa e concentrada. O trabalho consolida a base analítica necessária para estudar existência, unicidade e regularidade de soluções nesse contexto, revelando fenômenos como a não existência de solução para certos expoentes críticos, conforme demonstrado por Bénilan e Brezis. *Co-authors:* Prof. Dr. Adilson Eduardo Presoto; Universidade Federal de São Carlos.Prof. Dr. Olimpio Hiroshi Miyagaki; Universidade Federal de São Carlos.

Super-Takens: A Delay Embedding Theorem for Supermanifolds

Cristhian Paúl Neyra Salvador

Universidade Federal de São Carlos, Brasil

Takens' celebrated 1981 theorem states that, for a generic diffeomorphism of a compact m-manifold M and a generic observable $h \in C^\infty(M)$, the delay coordinate map $x \mapsto (h(x), h(\phi x), \ldots, h(\phi^(2m)(x)))$ is an embedding of M into $\mathbb{R}^(2m+1)$. This result is a cornerstone of nonlinear time-series analysis and dynamical reconstruction theory.

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Takens' celebrated 1981 theorem states that, for a generic diffeomorphism φ of a compact m-manifold M and a generic observable $h \in C^\infty(M)$, the delay coordinate map $x \mapsto (h(x), h(\varphi x), \ldots, h(\varphi^{2m}(x)))$ is an embedding of M into $\mathbb{R}^{2m+1}$. This result is a cornerstone of nonlinear time-series analysis and dynamical reconstruction theory.

We present a super-geometric analogue of this theorem in the category of compact $(p|q)$-dimensional supermanifolds. The central obstacle is structural: purely even observables are blind to the soul, so a naive transposition of the classical delay map fails to detect the odd geometry. Our resolution employs $\mathbb{R}^{(1|q)}$-valued observables, combining one even component for the body and q odd components for the fiber, which jointly resolve both sectors.

Main Theorem (Super-Takens). Let $\mathcal{M} = (M, \mathcal{O}_\mathcal{M})$ be a compact supermanifold of dimension $(p|q)$ with $p, q \geq 1$. There exists a residual subset $\mathcal{R} \subset \mathrm{SDiff}(\mathcal{M}) \times \mathrm{Hom}_S(\mathcal{M}, \mathbb{R}^{(1|q)})$ such that for every $(\varphi, h) \in \mathcal{R}$, the delay map $\Phi^{2p} : \mathcal{M} \to \mathbb{R}^{(2p+1)|(2p+1)q}$ is an injective superimmersion: the body is a classical Takens embedding, the odd superdifferential is fiber-injective, and Φ^{2p} is a monomorphism on S-points functorially in S.

The proof combines classical Takens with parametric transversality on Fréchet spaces of supermorphisms and Baire-genericity arguments. The result specializes to Takens 1981 when $q = 0$. Sharpness of the target dimension and extensions to non-split and DeWitt–Rogers settings are discussed.

Extraction and Analysis of Agronomic Variables Using Digital Image Processing

Eder Pereira Neves

Universidade Estadual de Mato Grosso do Sul, Brazil

Advances in techniques for analyzing agronomic variables have driven the development of methodologies based on digital image processing, particularly using RGB and hyperspectral images, which are capable of extracting characteristics correlated with the performance

of cultivars. In this context, this study presents a methodology applied to images obtained from agronomic experiments conducted at the State University of Mato Grosso do Sul, Cassilândia Campus, with the aim of analyzing variables using techniques for processing and extracting textural attributes. The proposed methodology is divided into two main stages: preprocessing and processing. In the preprocessing stage, the algorithm performs segmentation of the region of interest, highlighting only the relevant parts of the cultivar. Next, in the processing stage, the segmented image is converted to grayscale and subjected to the Canny edge detector, resulting in a matrix representation of its structures. Subsequently, the Gray-Level Co-occurrence Matrix (GLCM) technique is applied, from which Haralicks textural descriptors are extracted. The obtained descriptors are statistically compared with variables of the analyzed cultivars. The results show a strong correlation between the extracted textural attributes and the agronomic variables under study, highlighting the effectiveness of the proposed methodology as a tool to support agronomic analysis based on digital images. *Co-authors:* Jorge González Aguilera - UEMS, Lislaine Cristiana Cardoso - UEMS, Marco Aparecido Queiroz Duarte - UEMS, Irene Coelho de Araujo - UEMS,

On the Specht Problem for Lie Algebras in Positive Characteristic: Non-finitely Generated T-Ideals and a Finite-Dimensional Example

Edgardo Bladimir Aguirre Rodriguez

Universidade Federal de São Carlos, Brazil

The Specht problem asks whether the T-ideal of polynomial identities of a given algebra is finitely generated. While this problem has a positive solution in the associative case, its behavior for Lie algebras remains only partially understood. In characteristic zero, the problem is still open, whereas in positive characteristic the situation is markedly different.

In this talk, we discuss constructions of non-finitely generated T-ideals in Lie algebras over fields of positive characteristic. In particular, we revisit a result of Drensky, which provides examples of non-finitely generated T-ideals in the free Lie algebra. Building on these ideas, we present a finite-dimensional Lie algebra of dimension 2p+3 whose T-ideal of polynomial identities is not finitely generated.

This example shows that the failure of the Specht property is not restricted to infinite-dimensional or highly pathological cases, but can already occur in relatively small dimensions. Our approach highlights structural mechanisms behind the non-finite generation of T-ideals in positive characteristic, contributing to a deeper understanding of polynomial identities in Lie algebras.

These results illustrate the contrast between characteristic zero and positive characteristic, and provide further evidence of the complexity of the Specht problem in the Lie setting.

Spectral Gap Estimates for a Degenerate Limit Operator via Truncated Approximations

Elaine Andressa Tavares de Lima

Universidade de São Paulo, Brazil

We investigate the spectral properties of a class of degenerate elliptic operators arising from thin domains with an outward peak. By introducing a family of truncated problems, we first establish their convergence to the original degenerate problem. We then analyze the spectral structure of the truncated operators and derive uniform spectral gap estimates through asymptotic analysis. By passing to the limit, we demonstrate that the spectral gap structure is preserved in the degenerate case, offering a robust framework for addressing singular spectral problems. *Co-authors:* Bianca Paolini Lorenzi - Universidade de São Paulo - IME-USP; Marcone Corrêa Pereira - Universidade de São Paulo - IME-USP

Ground states for a p-Schrodinger-Poisson system with indefinite potential

Erick Ariel Altamirano Carpio

Universidade Estadual de Campinas

By a direct method it's proved the existence of sign-changing and non-negative ground states for the p-Schrödinger-Poisson system

$$\begin{cases} -\Delta_p u + V(x)|u|^{p-2}u + K(x)\phi(x)|u|^{p-2}u = a(x)|u|^{q-2}u, & x \in \mathbb{R}^N, \\ -\Delta_p \phi = K(x)|u|^p, & x \in \mathbb{R}^N, \end{cases}$$

where $N \in \mathbb{N}$, $2p = -1 + \sqrt{1+8N} < q < p^*$ and the potentials $a \neq 0$ and V verify conditions that allow them to be sign-changing. Here Δ_p denotes the p-Laplace operator. We show that the sign-changing ground state has two nodal domains. The energies of the found ground state solutions verify Weth's energy doubling property. *Co-authors:* Erick Altamirano-Carpio (Universidade Estadual de Campinas, Brazil), Juan Mayorga-Zambrano (Yachay Tech University, Ecuador), Henry Cumbal-López (Universidad Técnica de Ambato, Ecuador) and Jeancarlos Delgado-Ochoa (Yachay Tech University,Ecuador)

Gamificação e Tecnologias Digitais como Estratégias de Retenção Discente no Ensino de Engenharia: O Projeto High Math

Felipe Dondoni Reinock

Instituto Federal do Espírito Santo IFES Campus São Mateus, Brazil

A disciplina de Cálculo 1 configura-se como um dos principais gargalos nos cursos de Engenharia, apresentando elevados índices de reprovação que impactam diretamente na evasão acadêmica. Este estudo apresenta o desenvolvimento da plataforma High Math como uma intervenção tecnológica voltada à promoção da permanência discente. A pesquisa utilizou uma abordagem mista, fundamentada em análise documental no IFES - Campus São Mateus (2022-2024) e questionários aplicados a 34 estudantes e 4 docentes. O diagnóstico revelou que a defasagem na matemática básica, a dedicação extraclasse insuficiente com a maioria dos alunos estudando menos de três horas semanais e fatores psicológicos, como ansiedade e síndrome do impostor, são as principais barreiras ao sucesso acadêmico. Verificou-se que a evasão é acentuada na Engenharia Elétrica após as avaliações iniciais, enquanto na Engenharia Mecânica predomina a retenção por insuficiência de nota. Como solução, a plataforma High Math integra gamificação por meio de um jogo em Scratch com mecânicas de RPG, onde o progresso narrativo depende da resolução de problemas matemáticos. A ferramenta disponibiliza suporte via Inteligência Artificial, calculadoras simbólicas e geradores de gráficos para facilitar a visualização de conceitos abstratos. Conclui-se que a integração desses recursos favorece a aprendizagem autônoma e o engajamento, auxiliando ingressantes de Engenharia a superarem lacunas formativas e estabelecerem rotinas de estudo sustentáveis, contribuindo para a redução da evasão institucional. *Co-authors:* Davi

Francisco Pirola - Instituto Federal do Espírito Santo IFES Campus São Mateus;Alan Hafif Helal - Instituto Federal do Espírito Santo IFES Campus São Mateus.

Limit cycles of continuous-discontinuous piecewise differential systems formed by two Hamiltonian systems and separated by a non-regular line

Fernanda dos Anjos Félix Becatti

Universidade Federal de Goiás, Brazil

We consider a class of continuous-discontinuous Hamiltonian systems, and we determine the maximum number of limit cycles that such systems can have. The piecewise vector fields are separated by a non-regular line $L = L_1 \cup L_2 = \{(x, 0) : x \geq 0\} \cup \{(x, y) : y = (\tan \alpha)x \geq 0\}$. We impose the hypotheses of continuity on the line L1. The non-regular line L splits the plane into two regions. In each region delimited by L, we consider polynomial Hamiltonian vector fields. The maximum number of limit cycles is given in function of the degree of the polynomial vector fields. *Co-authors:* Bruno Freitas (Universidade Federal de Goiás);

Deysquele Ávila (Universidade Federal de Goiás); Jaume Llibre (Universitat Autònoma de Barcelona).

The Frontiers of Hans Conjecture

Guilherme da Costa Cruz

Universidade de São Paulo, Brazil

In 2006, Y. Han proposed the following conjecture (still unsolved) about a finite dimension-alalgebra: if the dimension of its Hochschild homology is finite, then its global dimension isalso finite. In the poster presentation, I will give an overview of the partial answers givento this problem, including examples that satisfy it such as commutative, monomial andgroup algebras and extensions of algebras which preserve Hans property. Besides that,I will try to present how this conjecture behaves in a broader realm of algebras, calledpseudocompact algebras (i.e. limits of finite-dimensional algebras), and what can be saidespecially about algebras of profinite groups. This is based on my work as a Master/PhDstudent under the supervision of Kostiantyn Iusenko.

A Second-Order Augmented Lagrangian Method on Riemannian Manifolds with Convergence to Weakly Stationary Points

Hilal Ahmad Bhat

Universidade de Sao Paulo, Brazil

We propose a Riemannian extension of second-order sequential optimality conditions of AKKT2 type and develop a second-order augmented Lagrangian framework on smooth, complete Riemannian manifolds. Under a suitable weak constraint qualification, we show that every accumulation point of the sequence generated by the method satisfies a weak second-order stationarity condition. The analysis combines intrinsic Riemannian geometry with sequential optimality concepts, and the results are supported by numerical experiments on standard manifolds such as the sphere, the Stiefel manifold, and the manifold of symmetric positive definite matrices. *Co-authors:* Gabriel Haeser from Universidade de Sao Paulo and Orizon Pereira Ferreira from Federal University of Goias

Demonstração interativa do Teorema de Dandelin-Quetelet para cônicas: um applet no GeoGebra

Hissa, Rafael Peixoto

Universidade Estadual do Norte Fluminense Darcy Ribeiro, Brazil

This paper presents a self-instructional applet developed in GeoGebra for the demonstration of the Dandelin-Quetelet Theorem, specifically focusing on the ellipse case. The resource is designed for undergraduate students and mathematics teachers, aiming to facilitate the geometric interpretation of conic sections through 3D visualization. The tool

is based on the existence of two spheres simultaneously tangent to the cutting plane and the cone, where the points of tangency coincide with the foci of the ellipse. The interface is organized into 12 sequential steps managed by a slider: steps 1 to 11 are dedicated to the theoretical foundation and formal demonstration, while step 12 allows for the dynamic exploration of variables, such as plane inclination and cone radius. Full comprehension requires prior knowledge of triangle congruence and tangent lines to spheres. The work includes a QR code for immediate access to the applet, enabling direct interaction with the geometric objects: geogebra.org/m/b5gazux9.

Efficient Evaluation for AI Control via Subsampling

Iara Cristina Mescua Castro

School of Applied Mathematics, Getulio Vargas Foundation, Brazil

Evaluating AI control protocols requires running a safety pipeline across a combinatorial grid of P problems, C protocol configurations, and K adversarial strategies; full evaluation scales as $P \cdot C \cdot K$ and is often infeasible. We adapt the PromptEval paradigm to this setting, enabling estimation of safety and usefulness from a budget of $E << P \cdot C \cdot K$ executions.

Our method has two parts. First, a structured logistic model on the logit scale uses additive latent factors to capture problem-level susceptibility and solvability, a low-dimensional protocol-strength function of configuration covariates, and a scalar attack effect; parameters are fit by maximum likelihood on the observed subset and used to impute outcome probabilities across the full grid. Second, a balanced subsampling algorithm iteratively selects triples by prioritizing the least-observed problem, configuration, and strategy to approximately equalize marginal coverage and reduce estimator variance compared to uniform sampling. Safety is estimated by Monte Carlo simulation over imputed scenario-length products; usefulness is reported as a normalized mean correctness rate. On Control Arena (code-sabotage tasks, three attack strategies) usefulness estimates remain accurate at $40\% - 80\%$ of the full budget. Safety estimation degrades for rare tail events, indicating a need for improved tail modeling. The approach shows promise for low-budget surrogate evaluation in AI safety while highlighting current limitations for reliable tail-risk quantification.

Benchmarking Geodesic Computation on Parametrized Surfaces: A Comparison of SageMath and MATLAB

Iara Cristina Mescua Castro

School of Applied Mathematics / Getulio Vargas Foundation

We present a reproducible benchmark comparing SageMath and MATLAB for two core problems in computational differential geometry: geodesic integration and geodesic distance computation on parametrized surfaces. The study focuses on three representative examples: the sphere, the torus of revolution, and the ellipsoid of revolution, chosen to cover increasing geometric complexity while keeping the experiments interpretable.

In both environments, we implement the same pipeline: construction of the metric from a surface parametrization, computation of the Christoffel symbols, and numerical solution of the geodesic equations as a first-order ODE system. Geodesic distance is computed by single shooting, where the initial direction and travel time are optimized so that the geodesic reaches a prescribed target point.

The comparison is organized around three criteria: accuracy, efficiency, and robustness. On the sphere, results are validated against known analytical geodesics and exact distance formulas. OOn the torus and ellipsoid, accuracy is assessed against converged high-precision reference solutions, complemented by geometric diagnostics such as energy drift, which help quantify how well the numerical trajectories preserve the intrinsic structure of the geodesic flow. Efficiency is measured by runtime and number of ODE evaluations, while robustness is evaluated through convergence and failure behavior across systematic tolerance sweeps and fixed test cases. The benchmark is designed so that both platforms are tested under matched parametrizations, solver settings, tolerances, and initial data. This allows us to isolate how geometric complexity affects numerical performance and to identify the practical strengths and limitations of each environment for geodesic computation.

Effects of Boundary Conditions on the Quantum Detection

Jefferson Monção da Silva

Universidade Estadual de Campinas, Brazil

In this work, we investigate how different boundary conditions influence the transition rate of an Unruh-DeWitt detector coupled to a scalar field. The system is analyzed in a static spacetime with cylindrical symmetry, divided by a singular shell into two regions: a flat inner region and an outer region with a conical metric. The field dynamics are treated through Sturm-Liouville operator theory over two intervals, allowing for the definition of a family of self-adjoint boundary conditions at the singular boundary, characterized by a real parameter β. We calculate the response function for a detector at rest positioned at the center of the flat region. Our results demonstrate that the detector's transition rate is sensitive to the choice of boundary condition (the value of β), even in situations where there is no classical interaction between the detector and the junction surface during the interaction time. This highlights the non-locality of the quantum vacuum and the physical relevance of self-adjoint extensions in spacetimes with singularities. *Co-authors:*

Jefferson Monção da Silva; João Paulo Pitelli Manoel

Conformal geometry of complete quasi Yamabe gradient solitons

João Francisco da Silva Filho

Universidade da Integração Internacional da Lusofonia Afro-Brasileira

In this work, we study the conformal geometry of complete quasi Yamabe gradient solitons, which correspond to an interesting generalization for gradient Yamabe solitons. More precisely, we present a rigidity result for nontrivial complete quasi Yamabe gradient solitons with constant scalar curvature. Moreover, we deduce a characterization for complete quasi Yamabe gradient solitons with constant scalar curvature under the assumption that the potential function admits a critical point. Finally, we prove that quasi Yamabe gradient solitons can be conformally changed to constant scalar curvature. *Co-authors:* João Francisco da Silva Filho (Unilab); Larissa Braga Fernandes (USP)

Boundedness of the solutions of functional Volterra-Stieltjes integral equations

Jucileide dos Santos

No affiliation

In this poster, we will discuss some of the qualitative and asymptotic properties of the solutions of a class of Volterra-Stieltjes functional integral equations with delay, given by

$$\begin{cases} x(t) = \phi(0) + \displaystyle\int_{\tau_0}^{t} a(t,s) f(x_s, s)\, \mathrm{d}g(s), \quad t \geqslant \tau_0 \\ x_{\tau_0} = \phi, \end{cases} \tag{1}$$

where the integral on the right-hand side is considered in the Perron-Stieltjes sense. We will present results on the boundedness for solutions of the Volterra-Stieltjes functional integral equation given by (1) with finite delay, using Lyapunov functionals. Since this equation generalizes fractional equation models, impulsive equations, and viscoelastic theory models, we will also present concrete applications of these results in such contexts. *Co-authors:* Rogelio Grau Acuna (UniNorte/Colômbia) and Jaqueline Godoy Mesquita (IMECC/Unicamp)

Comparative analysis of the Gradient Descent Method with Armijo Line Search (GDA) and the Spectral Method with a Nonmonotone Variant (GBB) for unconstrained optimization problems

Julián Andrés López Moreno

Universidade Estadual de Campinas, Brazil

Este trabalho apresenta uma análise comparativa entre o método do Gradiente Descendente com busca linear de Armijo (GDA) e o método espectral de Barzilai-Borwein com estratégia não monotônica (GBB), aplicados a problemas de otimização irrestrita. O estudo foi realizado sobre um conjunto representativo de 30 problemas da biblioteca PyCUTEst, abrangendo diferentes estruturas funcionais, escalas dimensionais e níveis de não linearidade. A avaliação considerou métricas de desempenho como número de iterações, norma final do gradiente, tempo computacional, avaliações de função e perfis de desempenho. *Co-authors:* Miguel Santiago Luque Casallas

The IVP for the Evolution Equation of Wave Fronts in Chemical Reactions in Zhidkov Spaces

Juliana Mancini Sanches

Universidade Federal de Goiás, Brazil

In this work, we study the initial-value problem for an equation of evolution of wave fronts in chemical reactions in Zhidkov spaces. We show that the associated initial value problem is locally and globally well-posed in Sobolev spaces, with Initial Data in Zhidkov Spaces. As a consequence, we can also solve it with data Borel-type.

Comparative analysis of the Gradient Descent Method with Armijo Line Search (GDA) and the Spectral Method with a Nonmonotone Variant (GBB) for unconstrained optimization problems

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Ambos os métodos foram implementados em Python sob condições experimentais uniformes e posteriormente submetidos a uma etapa de otimização de parâmetros por meio de busca em malha. Os resultados evidenciam uma superioridade consistente do método GBB na maioria dos cenários avaliados. Na configuração base, o método espectral apresentou convergência significativamente mais rápida, alcançando menores tempos computacionais, maior precisão numérica e norma do gradiente inferior em média geométrica quando comparado ao GDA.

A análise dos perfis de desempenho mostrou que o GBB resolveu 89,7% dos problemas, enquanto o GDA alcançou apenas 41,4%. Embora o método de Armijo tenha demonstrado robustez em alguns casos particulares, especialmente em problemas mal condicionados, o método espectral destacou-se por sua maior eficiência global. Conclui-se que a combinação entre atualização espectral e busca não monotônica constitui uma alternativa computacionalmente mais eficiente para problemas de otimização não linear irrestrita, particularmente em cenários de média e grande escala. *Co-authors:* Miguel Santiago Luque Casallas

Beyond Analogy: A Mathematical Analysis of Equivalence and Order Relations in Behavioral Science

Kimberly da Silva Rocha

Universidade de Brasília, Brazil

The concept of "equivalence" is widely used in behavior analysis, largely due to the work of Murray Sidman. However, the alignment between Sidmans "stimulus equivalence" and the formal, mathematical definition of an "equivalence relation" warrants conceptual analysis. This study investigates the mathematical properties (reflexivity, symmetry, and transitivity) as defined in set theory and compares them to the operational procedures used by Sidman and colleagues to test for emergent behavioral relations. We argue that while Sidmans paradigm tests for emergent stimulus control, the resulting phenomenon is a behavioral process mediated by contingencies, rather than a direct application of the formal mathematical structure. Furthermore, we extend this analysis to "order relations", comparing their mathematical definition to their application in Relational Frame Theory (RFT). We conclude that while mathematics provides a useful heuristic and language for describing behavioral patterns, a precise conceptual distinction between formal mathematical relations and emergent psychological phenomena may clarify theoretical discussions in both psychology and mathematics. *Co-authors:* Leandro Nery de Oliveira, Jorgeane da Mota Trindade de Oliveira, Júlio Cesar Coelho de Rose

Exploring Period Functions in Planar Polynomial Systems

Leandro de Jesus Nascimento Bacelar

Universidade de São Paulo, Brazil

The main goal of this work is to study the period function of planar differential systems with a linear type center at the origin. We present a methodology to obtain the series expansion of the period function by analyzing the system in polar coordinates. Furthermore, some illustrative examples are discussed to demonstrate the applicability of the method.

Colored Tverberg Theorems: Historical Perspectives and New Results

Leandro Vicente Mauri

UFSCar (Federal University of São Carlos)

The Colored Tverberg Theorem is one of the central results in topological combinatorics, connecting combinatorial geometry, algebraic topology, and equivariant methods. Since the pioneering works of Bárány, Larman, Živaljevi'c, and Vre'cica, several colored versions and refinements of Tverberg-type theorems have been developed, leading to important advances and new open problems.

This work provides a brief historical overview of the development of Colored Tverberg-type theorems, emphasizing the transition from the classical Tverberg theorem to its topological and colored counterparts.

Furthermore, we present two recent results obtained by the authors. In the first work, we prove a new constrained version of the Colored Tverberg Theorem in which additional restrictions are imposed on the rainbow faces, specifically by limiting the number of faces containing vertices of each color class.

In the second work, we prove relatives of both the original and the optimal (Type B) versions of the Colored Tverberg Theorem of Živaljevi'c and Vre'cica, modifying these results in two different ways. First, we extend the original theorems beyond the prime power setting by proving that these theorems remain valid when the number of rainbow faces satisfies $q = p^n - 1$. Second, we allow some rainbow simplices to have smaller sizes than in the classical theorems, replacing the condition $|C_i| = 2q-1$ by $|C_i| \in \{2q-2, 2q+1\}$.
Co-authors: Edivaldo Lopes dos Santos (UFSCar); Denise de Mattos (ICMC-USP)

Periodic orbits in slow–fast piecewise linear Hamiltonian systems

Luan Lima da Silva

Universidade Federal de Goiás, Brazil

We prove analytically the existence of crossing periodic orbits for a family of piecewise linear slow-fast Hamiltonian systems defined in $\mathbb{R}^4$ when $\varepsilon > 0$ is sufficiently small; these systems serve as mathematical models for many phenomena in physics. We provide a necessary generic condition for the existence of crossing periodic orbits. We discuss the relationship between the crossing periodic orbits and the homoclinic orbits existing in these systems. In addition, we investigate the existence and non–existence of crossing periodic orbits through appropriately chosen subsets of the discontinuity hypersurface for $\varepsilon > 0$ sufficiently small. This paper completes analytically some preliminary results intuited numerically from the paper by Kazakov, Kulagin and Lerman.

Family of piecewise linear slow-fast Hamiltonian systems:

$$\begin{aligned} \varepsilon \dot{x} &= y, \\ \varepsilon \dot{y} &= -x - w, \\ \dot{z} &= x, \\ \dot{w} &= \begin{cases} -z/a, & \text{if } \ z \leq a, \\ (z-1)/(1-a), & \text{if } \ z \geq a; \end{cases} \end{aligned} \tag{1.1}$$

where $0 < a < 1$ and $\varepsilon > 0$ small. *Co-authors:* Jaume Llibre - Universidad Autónoma de Barcelona (UAB)

Mathematical Modeling of Immune Response and Degeneration in Alzheimer's Disease: A Kinetic Theory Approach

Luiza Santos Morin

Universidade do Minho (Portugal) / Universidade Federal do Rio Grande (Brazil)

This work presents a mathematical model for describing the dynamics of the biological factors responsible for the progression of Alzheimer's Disease (AD), by applying systems of partial and ordinary differential equations grounded in the principles of kinetic theory. The research focuses on the complex interaction between key biomarkers and immune system cells, such as T lymphocytes (CD4+ and CD8+ cells), amyloid-beta aggregates representing damage-associated molecular patterns (DAMPs), effector and regulatory T cells, as well as the role of microglia and astrocytes. The objective is to analyse the direct correlation of these populations with neuronal decline and cognitive impairment. In order to capture the nature and critical thresholds of the pathology, the model incorporates step functions, which are able to model the biological triggers that give rise to neurodegeneration. The application of kinetic theory provides the necessary framework to describe the interaction between cells through the rates of collision, proliferation, destruction of cells and variation of cellular activity. We performed a stability analysis of the equilibrium points in specific cases, seeking to validate the numerical solutions with literature data on the disease's behaviour over time. The results indicate that the inclusion of discontinuities controlled by step functions offers a more faithful representation of the non-linear progression reported in the bibliography, contributing to the development of computational tools

for understanding neurodegenerative evolution. *Co-authors:* Maria Piedade Machado Ramos, Universidade do Minho; Carolina Paula Baptista Ribeiro, Universidade do Minho; Adriano de Cezaro, Universidade Federal do Rio Grande

Necessary KKT Conditions for Vector Optimization via a Sequential Penalty Approach under LICQ and CRCQ

Mahwash Aftab

Universidade de Sao Paulo

We extend the elementary four-step penalty proof of Lagrange multipliers to vector optimization problems under two constraint qualifications: the linear independence constraint qualification (LICQ) and the constant rank constraint qualification (CRCQ). The proof uses an auxiliary variable to scalarize the problem and handles both equalities and inequalities, recovering the KarushKuhnTucker conditions. *Co-authors:* Prof. Gabriel Haeser , Universidade de Sao Paulo, Brasil ; Dr. Akhlad Iqbal, Aligarh Muslim University, India.

DirichletCorrection: um pacote em R para correção de viés em regressão Dirichlet

Marea Cunha de Albuquerque

Universidade Federal de Goiás, Brazil

A regressão Dirichlet multivariada é amplamente utilizada para modelar dados composicionais, como proporções que somam 1. Entretanto, a inferência nesses modelos geralmente se baseia em aproximações assintóticas de primeira ordem, que podem apresentar menor precisão em amostras pequenas ou moderadas, comprometendo a qualidade das estimativas e dos testes de hipóteses. Como alternativa, refinamentos assintóticos de ordem superior podem ser empregados para melhorar a acurácia inferencial nesses cenários. Nesse contexto, Melo et al. (2020) propõem uma correção de viés baseada na expressão geral de Cox and Snell (1968). O presente trabalho tem como objetivo desenvolver um pacote no ambiente R, denominado Dirichlet Correction, que implementa de forma eficiente essas correções de viés em modelos de regressão Dirichlet. Para isso, o pacote foi construído com foco em eficiência computacional, utilizando operações matriciais otimizadas e métodos numéricos robustos para garantir convergência em problemas com múltiplos parâmetros. Além disso, foram realizados estudos de simulação de Monte Carlo para avaliar o desempenho da correção proposta, evidenciando reduções de viés e maior estabilidade numérica em diferentes cenários amostrais. O pacote é de código aberto, disponível no GitHub,

e visa facilitar a aplicação prática de refinamentos assintóticos em modelos de regressão Dirichlet. *Co-authors:* Tatiane Ferreira do Nascimento Melo; Instituto de Matemática e Estatística - Universidade Federal de Goiás

Brazilian Mathematical Community: a brief history

Mariana Feiteiro Cavalari

Universidade Federal de Itajubá, Brazil

This note examines the historical processes that led to the emergence, consolidation and internationalization of the Brazilian mathematical community during the twentieth century. Rather than treating this development as the cumulative result of individual achievements, the analysis adopts an institutional and sociological perspective, focusing on the mechanisms through which a coherent and durable scientific community was formed. Three interrelated dimensions structure the discussion: the establishment of institutions dedicated to training mathematicians and supporting research; the creation of national information and communication infrastructures; and the circulation of people, ideas, and practices through international exchanges.University-based mathematics programmes created in the 1930s in São Paulo and Rio de Janeiro addressed the foundational problem of training and reproducing researchers. From the late 1950s onward, the Brazilian Mathematics Colloquia played a central role in consolidating the community by providing regular national forums for intellectual exchange, standardising research expectations, and linking mathematicians across regions and generations. Research institutes such as the Institute of Pure and Applied Mathematics (IMPA) contributed to this process by strengthening postgraduate training and international integration.By situating these developments within a broader comparative and international context, the article argues that the Brazilian case illustrates how mathematical communities in the Global South are actively constructed through sustained institutional investment, strategic integration into global networks, and the development of robust communication infrastructures. In this light, later markers of international recognitionsuch as Brazils position within the International Mathematical Union and individual distinctionsare best understood as outcomes of long-term structural processes rather than isolated successes. *Co-authors:* Valeria C V de Paiva, Topos Institute, Berkeley, USA

Infinite-Piecewise Maps via Conformal Iterated Function Systems

Matheus Gonçalves Cassiano da Cunha

Universidade Estadual de São Paulo, Brazil

We study a class of maps $\phi : W \subset [-1, 1] \to [-1, 1]$, where W is a countable union of (non-degenerate) pairwise disjoint closed isolated intervals, whose restrictions $\phi|_J$ to intervals J

of $\mathcal{W}$ are uniformly Hölder and such that the growth of the derivative of ϕ along the pre-images of any point is polynomial. By using the tools of the theory of conformal iterated function systems (CIFS), we study the invariant set generated by this dynamics and prove, in particular, that its Hausdorff dimension is situated between 0 and 1, that its dynamics is topologically conjugate to a Bernoulli shift with a countable alphabet and that there exists a unique conformal measure for (Λ, ϕ). As an application, we deduce some results for the theory of piecewise smooth vector fields where these maps arise naturally as first return maps of certain dynamics. *Co-authors:* Douglas Duarte Novaes (IMECC - Unicamp); Gabriel Ponce (ICMC - USP)

Convergência de Algoritmos de Primeira Ordem com Momentum sob a Perspectiva de um Método de Descida do Gradiente Inexato

Miguel Santiago Luque Casallas

Unicamp

Neste trabalho, propõe-se uma modificação do algoritmo de descenso de gradiente inexato com momento, denominada IGDm com atraso, projetada para resolver problemas de otimização onde o gradiente exato não está disponível. Diferentemente do algoritmo original, que constrói os pontos de extrapolação a partir da iteração atual, o esquema proposto utiliza a iteração anterior como ponto base. Essa mudança introduz um efeito de inércia que melhora notavelmente a estabilidade e permite empregar tamanhos de passo até o dobro do passo ótimo teórico.

O algoritmo é implementado por meio de aproximações do gradiente por diferenças finitas, com uma estratégia adaptativa para controlar a precisão. Seu desempenho é avaliado em dois problemas representativos: regressão por mínimos quadrados e restauração de imagens não convexa, considerando cenários com e sem ruído nas avaliações da função.

Os resultados experimentais demonstram que o IGDm com atraso é significativamente mais robusto que a versão original. Na presença de ruído e problemas mal condicionados, o algoritmo proposto converge de forma estável enquanto o original diverge. As principais vantagens são: maior estabilidade frente ao ruído, capacidade de usar passos maiores sem divergir, melhor desempenho em esquemas de momento tipo Nesterov e robustez geral em problemas convexos e não convexos. Essas características tornam o IGDm com atraso uma ferramenta promissora para aplicações reais onde o gradiente exato não está disponível e as avaliações da função são ruidosas.

An introduction to deep learning and Riemannian optimization

Monica Maria Funk Drechsler

Universidade de São Paulo, Brazil

Riemannian optimization determines methods for finding minimum points in functions whose domain are manifolds. On the other hand, supervised machine learning such as deep learning can be seen as an optimization problem. In this work, we present the fundamental concepts of both areas. We talk about Riemannian optimization algorithms, theorems, and conditions for convergence. Concurrently, we present the formal definitions of neural networks, their training method, and the universal approximation theorem, which shows the capability of neural networks to approximate continuous functions. We combine both areas by testing optimization algorithms on simple neural networks for classification problems using the Oblique manifold as a domain and presenting their results. *Co-authors:*

Marcos Martins Alexandrino da Silva, professor of IME USP

Applying Markowitz Theory and Operations Research for Modeling an Optimal Investment Portfolio

Pedro Henrique Cardoso

Federal University of São Carlos (UFSCar)

The aim of this study was to construct an investment portfolio composed of assets traded on the B3 (Brazilian Stock Exchange) using Operations Research and theories from the field of Economics as the main tools, in particular Markowitzs Modern Portfolio Theory. Two types of Mathematical Modeling were used to model the problem: Linear Optimization and Nonlinear Optimization. The solution to the linear problem was provided using the Simplex Method, with the aid of MATLAB software, while the solution to the non-linear problem was obtained using the Gradient Method and Newtons Method, with the aid of the free software GNU Octave. The data included in the research refers to an analysis of their performance in the second half of 2024 and the first half of 2025, detailing the ten best performing assets during this period, and selecting the five assets with the best correlations. The results obtained indicate that a diversified portfolio, structured based on mathematical models and historical data, can present superior performance when compared to a random selection of assets. Furthermore, it was observed that Nonlinear Optimization presented more consistent results when compared to Linear Optimization, since many economic phenomena exhibit nonlinear behavior, which allows for a more appropriate representation of financial market dynamics and, consequently, more precise results. *Co-authors:* Sadao Massago (DFQM - UFSCar); Aniela Fagundes Carrara (DEc - UFSCar); Deisemara Ferreira (DFQM - UFSCar); Geraldo Edmundo Silva Júnior (DEc - UFSCar); Vitor Pablo Cardoso (FAE Business School).

Computing low dimensional homologies from topological and number-theoretic methods

Thiago Verissimo Leal Gonçalves

Institute of Mathematics and Computer Science - University of São Paulo

A precise description of the homologies of certain groups provides numerous applications in various other areas of mathematics, such as number theory, hyperbolic geometry, the theory of modular and automorphic forms, algebraic topology, algebraic K-theory, and much more.

We explore some results achieved recently where, given a nonzero integer n, the second homology with coefficients in $\mathbb{Z}$ - the Schur multiplier - of the special linear group of order two over the domain $\mathbb{Z}[1/n]$ is calculated, provided n is divisible by one of the following special primes: $2, 3, 5, 7$, or 13. We describe our approach, emphasizing the techniques coming from topological and number-theoretic insights.

Furthermore, we discuss a generalization for Dedekind domains of arithmetic type, which is currently in preparation. *Co-authors:* Behrooz Mirzaii (Institute of Mathematics and Computer Science, University of São Paulo); Bruno Reis Ramos (Institute of Mathematics and Computer Science - University of São Paulo).

Maximal Monotone Operators

Tácio Fernandes Alves

UFBA

This poster focuses on the study of maximal monotone operators and their importance in the field of Optimization. It will be shown important concepts in both optimization and complex analysis, and how this important type of operator defines very powerful algorithms for solving general optimization problems. As this is an area that is activele studied in Brazil, important names will be mentioned and their contributions.

Programme

Programme - 7th BRICS Mathematics Conference

	18 August 2026 Tuesday	19 August 2026 Wednesday	20 August 2026 Thursday	21 August 2026 Friday
	(Fau Auditorium)			
08:00-09:00	**Registration**			
09:00-10:00	**Katrin Gelfert** Coexistence of hyperbolic of different types	**Arup Bose** Limiting spectral distribution of (symmetric) random matrices with independent entries	**Mapundi Banda** Flows in networked domains: mathematical insights from hyperbolic conservation laws	**Rama Govindarajan** Non-normality, translation-rotation coupling and chaos in particle-laden flow
10:00-10:30	**Coffee-break**			
10:30-11:30	**Zhiyu Tian** Space of rational curves on rationally connected varieties	**Pavel Zalesski** Profinite properties of residual finite groups and profinite genus	**Michael A. Henning** Domination in Regular Graphs	**Maxim A. Shishlenin** Digital twins of ultrasound tomography
11:30-12:30	**Yu-hong Dai** Optimization with Least Constraint Violation	**Elena Kudryavtseva** Topology of integrable systems on 4- and 6-manifolds	**Pedro da Silva Peixoto** A Century of Discretizing the Atmosphere: Numerical Methods in Weather and Climate Models, and the Role of BRICS	**Eunice Mphako-Banda** The Power of Polynomial Invariants: From Colouring to Entanglement
12:30-14:00	**Lunch break**		**Core Committee Meeting (Closed)**	***Closing***
14:00-14:30		**Sudhir R. Ghorpade** Zeros of multivariate homogeneous polynomials over finite fields		Distinguished Lecture Plenary Lectures Invited Lectures Contribuited Lectures Thematic sessions Poster sessions
14:30-15:00	**Jinyun Yuan** BRICS Mathematics A Journey of History, Collaboration, and Future	**Karin-Therese Howell** Life Just Outside Linearity: An Introduction to Near-vector Spaces	**Ronalda Benjamin** B-Fredholm theory in general Banach algebras	
15:00-15:30	**Alex Carlucci Rezende** Oscillation and monotonicity of the period function in piecewise linear systems	***Eduardo Cavalcante Tail*** Extrapolation in Survival Analysis under Right Censoring: An Extended Generalized Pareto-Type Approac	***Antonio Melo*** *Synchronization in coupled network systems: a survey*	
15:30-16:30	*Itaú Foundation* ***Alexandre Moreira*** *A Matemática em Perspectiva: Do Impacto Econômico à Realidade de Quem Ensina no Brasil.*	**Coffee-Break & Poster Session & Matemateca**		
16:30-17:30	**Coffee-Break & Poster Session & Matemateca**	**Thematic Sessions**		
17:30-18:30	***Opening Ceremony***			
18:30-19:30	**Artur Ávila** Julia sets of positive Lebesgue measure in dimensions one and two			
19:30	**Welcome Reception** (19h30-21h)			
20:00		Conference Dinner **Restaurante Bovinu'S Churrascaria**		

Thematic Session
(Bloco A - IME)

Session 1 - Recent Developments on Integrable Systems and Soliton Models

Organizers: Priscila Leal da Silva (UFSCar, Brazil), Igor Freire (UFSCar, Brazil), Zhijun Qiao (UTRGV, USA)

	19 August 2026 Wednesday (Room A241)	20 August 2026 Thursday (Room A132)
16:30-17:05	**Zhijun Qiao** Peakon and Beyond I: Scalar Form	**Enrique Reyes** The initial value problem of the KP hierarchy
17:05--17:40	**Wagner Cortes** Differential Calculus on the ring of generalized Colombeau numbers and results in ordinary differential equations	**Fabio Natali** Instability of the peaked traveling wave in a local model for shallow water waves
17:40--18:15	**Luiz Agostinho Ferreira** The hidden symmetries of Yang-Mills theory in (3 + 1)-dimensions	**Mahendra Prasad Panthee** On the well-posedness of the initial value problem for the MMT model
18:15--18:50	***Shuxia* Li** Lax Algebraic Representation for an Integrable Hierarchy	**Igor Leite Freire** Cauchy Problems Describing Pseudospherical Surfaces
18:50--19:25	**Priscila Leal da Silva** Explicit solutions for a Novikov equation	

Session 2 - Nonlinear Partial Differential Equations and Regularity Theory

Organizers: Jiazheng Zhou (UNB, Brazil), Jefferson Abrantes Santos (UFCG, Brazil), Zhizhang Wang (Fudan University, China)

	19 August 2026 Wednesday (Room A243)	20 August 2026 Thursday (Room A242)
16:30-17:00	***Zhizhang Wang*** *Inverse Hessian curvature flow in Minkowski space*	**Heming Jiao** Interior Hessian estimates for Hessian quotient equations in dimension three
17:00-17:30	**Carlos Alberto Pereira dos Santos** About positive solutions to degenerated logistic quasilinear-Schrödinger and Carrier problems	***Gustavo Ferron*** *A Critical Neumann problem with anisotropic p-Laplacian*
17:30-18:00	**Luis Henrique Miranda** Some aspects of regularity of solutions for certain elliptic systems	**Pedro Fellype Pontes** Regularity theory of almost-minimizers for vectorial functionals of Bernoulli-type
18:00-18:30	**João Vitor da Silva** Lipschitz regularity estimates of almost-minimizers for Alt–Caffarelli functionals with non-standard growth	**Jiazheng Zhou** Positive normalized solutions to a singular elliptic equation with a L^2-supercritical nonlinearity
18:30-19:00	***Tao Feng*** *Isolated Singularities in Hartree-Type Equations*	**Jefferson Abrantes Santos** Rigidity for Non-Uniformly Elliptic Equations in Planar Strip Domains
19:00-19:30	**Mayra Soares** Regularity Estimates for a Nonhomogeneous Free Boundary Interface Problem	

Session 3 - Dynamical systems and ergodic theory

Organizers: Anish Ghosh (Tata Institute of Fundamental Research, India), Yuri Lima (USP, Brazil)

	19 August 2026 Wednesday (Room A252)	20 August 2026 Thursday (Room A243)
16:30-17:10	**André de Carvalho** Surface dynamics and 3D geometry and topology: the horseshoe and its geometric limits	**Chaitanya Tappu** Mapping Class Group invariant metrics on the Marked Moduli Space
17:10-17:50	**Anindya Chanda** Sphere-filling Curves: from Cannon-Thurston Construction to Anosov-like Actions	**Rodolfo Gutiérrez-Romo** Conjugacy of affine extensions of interval exchange transformations
17:50-18:00	**Break**	
18:00-18:40	**Vaibhav Gadre** Theta simplicity of Lyapunov exponents for the diagonal flow on moduli spaces of flat surfaces	**Fan Yang** Margulis-like measures on expanding foliations: construction and rigidity
18:40-19:20	**Carlos Matheus** Euler characteristics of SL(2,Z)-orbit graphs of origamis of low genera	

Session 4 - Finite Fields and Applications

Organizers: Cícero Carvalho (Universidade Federal de Uberlândia, Brazil), Sudhir Ghor-pade (Indian Institute of Technology Bombay, India), Luciane Quoos (Universidade Federal do Rio de Janeiro, Brazil)

	19 August 2026 Wednesday (Room A259)	20 August 2026 Thursday (Room A259)
16:30-17:00	***Rodrigo Salomao*** *On singular and maximal curves over finite fields*	***Anuradha Sharma**** *Linear codes from simplicial complexes: Constructions and Applications*
17:00-17:30	***César Polcino*** *A survey on recent results on the applications of group algebras to Coding Theory*	***Pietro Speziali**** *Towards the classification of algebraic curves with transitive actions on Weierstrass points*
17:30-18:00	**Break**	
18:00-18:30	***Lucas Reis*** *Polynomials that are free of binomiais*	***Nazar Arakelian**** *Curves on Frobenius nonclassical loci of hypersurfaces*
18:30-19:00	***Luciane Quoos*** *A closed formula for the Geil-Matsumoto bound*	***Minjia Shi*** *The weight spectrum cardinality theory of linear codess*
19:00-19:30	***Sudhir R. Ghorpade*** *Schubert varieties and linear codes*	*Lingfei Jin* *A general framework of non-Reed-Solomon MDS Codes*

Speakers marked with * will give online talks.

Session 5 - Stochastic Processes on Graphs and Networks

Organizers: Anatoli Iambartsev (USP, Brazil), Fábio Machado (USP, Brazil)

	19 August 2026 Wednesday (Room A266)	**20 August 2026** Thursday (Room A267)
16:30-17:00	**Saye Khaniha** Hierarchical Clustering Algorithms on Point	**Pablo Gomes** The Truncation Question in Percolation of Words
17:00-17:30	**Conrado Costa** Passage Times for Partially Homogeneous Reflected Random Walks on the Quadrant	**José Hermenegildo** The Frog Model on Z with discrete Weibull lifetimes and random parameter p
17:30-18:00	**Artem Logachev** Strong Laws of Large Numbers for Random Variables Satisfying a Pairwise ρ-Mixing Condition	**Lucas Lima** Refinements of the Asymptotic Shape Theorem and Coexistence of Species on Random Geometric Graphs
18:00-18:39	**Gustavo de Carvalho** Coverage properties for the frog model on complete graphs	**Shangjie Yang** Cutoff of the simple exclusion process with inhomogeneous conductances

Session 6 - Mathematical and Computational Modeling

Organizers: Yulia Petrova (USP, Brazil), Maicon Ribeiro Correa (USP, Brazil), Lucas Franceschini (USP, Brazil), Joao G. C. Steinstraesser (USP, Brazil)

	19 August 2026 Wednesday (Room A268)	**20 August 2026** Thursday (Room A268)
16:30-17:00	**Lívia Souza Freire** New paradigms for turbulent flow modeling: stochastic mapping and resolvent analysis	**Sergey Tikhomirov** Fingering phenomenon in unstable displacement in porous media
17:00-17:30	**Ciro Campolina** The infinite-Reynolds limit of the 2D Navier–Stokes equations with no-slip boundaries	**Tatiana Danelon** Modeling nanoparticle-stabilized foam flow in porous media: Mathematical analysis and uncertainty quantification
17:30-18:00	**Giovanni Taraschi** On the application of goal-oriented error estimation to Mixed Finite Element methods	**Fabrício Simeoni de Souza** Efficient multiscale preconditioners for subsurface flow in porous media
18:00-18:15	**Break**	
18:15-18:45	**Alexandre Kawano** An Inverse Problem for Source Identification in a Coupled Acoustic Fluid–Euler–Bernoulli Beam Model	**Alfredo Gay Neto** Contact modeling with the master-master approach and application**s**
18:45-19:15	**Nelson Kuhl** An all-at-once formulation for the electrical resistivity problem	**Geovane Haveroth** Topology Optimization for Additive Manufacturing: Design and Fabrication

Session 7 - Symposium on Contemporary Differential Geometry at USP

Organizers: Marcos M. Alexandrino (Universidade de São Paulo, Brazil)

	19 August 2026 Wednesday (Antonio Gilioli Auditorium)	**20 August 2026** Thursday (Antonio Gilioli Auditorium)
16:30-17:00	**Xiaobo Liu** Mean Curvature Flow for Isoparametric Submanifolds in Hyperbolic Spaces	**Ivan Struchiner** Lie Theory and Cartan's Realization Problem
17:00-17:30		
17:30-18:00	**Marcelo Atallah** C⁰-rigidity of the Hamiltonian diffeomorphism group of symplectic rational surfaces	**Patrícia Marçal** When is a singular Finsler foliation actually Riemannian? The case of $(\alpha,beta)$ spaces
18:00-18:30		
18:30-19:00	**Leonardo Biliotti** Reduction Principles for Proper Actions.	**Clarice de Souza Ferreira Netto** Multiplicative sections of CA-groupoids
19:00-19:30		

Poster Sessions

	18 August 2026 Tuesday	**19 August 2026** Wednesday	**20 August 2026** Thursday
	(In front of the Fau Auditorium)		
15:30-16:30		**Hissa, Rafael Peixoto** **Iara Cristina Mescua Castro** **Jefferson Monção da Silva** **João Francisco da Silva Filho** **Jucileide dos Santos** **Julián Andrés López Moreno** **Juliana Mancini Sanches** **Kimberly da Silva Rocha** **Leandro de Jesus N Bacelar** **Leandro Vicente Mauri** **Luan Lima da Silva**	**Luiza Santos Morin** **Mahwash Aftab** **Marea Cunha de Albuquerque** **Matheus G Cassiano da Cunha** **Miguel Santiago Luque Casallas** **Monica Maria Funk Drechsler** **Pedro Henrique Cardoso** **Tácio Fernandes Alves**
16:30-17:30	**Anderson Mauro da Silva** **Bianca Paolini Lorenzi** **Bruno Mascaro** **Carlos Eduardo P Segantin** **Eder Pereira Neves** **Edgardo B Aguirre Rodriguez** **Elaine Andressa Tavares de Lima** **Erick Ariel Altamirano Carpio** **Felipe Dondoni Reinock** **Fernanda dos Anjos Félix Becatti** **Guilherme da Costa Cruz** **Hilal Ahmad Bhat**		