



2014

Caderno de Resumos



IV Workshop de Teses e Dissertações em Matemática

Caderno de Resumos

Realização:



Apoio:



Bem vindo

Em sua quarta edição, o Workshop de Teses e Dissertações em Matemática tem como finalidade promover a integração e a divulgação da pesquisa do programa de pós-graduação em matemática do ICMC-USP. Consiste em um momento propício para discussões, uma vez que os alunos em fase final da produção de sua tese ou dissertação, são incentivados a ministrarem palestras divulgando os resultados obtidos em suas pesquisas.

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Sumário

Palestra de Abertura	11
Palestras	15
Alex Carlucci Rezende Topological classification of quadratic vector fields with semi-elemental saddle-nodes	17
Andrea Sacramento Curves on a timelike surface	17
Camila Mariana Ruiz On the topology of Morin singularities	17
Carlos Alberto Siqueira Lima Hausdorff dimension of quasi-arcs	18
Gabriel Ponce On the behavior of partially hyperbolic teenagers	19
Ginnara Mexia Souto Qualitative properties of impulsive dissipative semidynamical systems	19
Giuliano Angelo Zugliani Global solvability of involutive systems	19
Ingrid Sofia Meza Sarmiento Classification of singular levels and Morse Bott integrable systems on surfaces	20
Jorge Alberto Coripaco Huarcaya Non-degenerate ideals in the ring of polynomials	20
José Carlos Valencia Alvites Rigorous Results on the Particle Spectrum of Lattice Quantum Chromodynamics Models in the Strong Coupling Regime	21

Luis Florial Espinoza Sánchez	
Surfaces in 4-space from the affine differential geometry viewpoint	22
Maria Amelia Hohlenwerger	
Bouquet of spheres for real Milnor fibrations	22
Mostafa Salarinoghabi	
Projection of space curves and their contact with circles	22
Northon Canevari Leme Penteadó	
Representing homotopy classes by maps with certain minimality root properties	23
Rafael Borro Gonzalez	
Global solvability of vector fields on the torus	23
Thaís Maria Dalbello	
Multitoric surfaces, Euler obstruction and applications	24
Thiago Henrique de Freitas	
Formal Local Cohomology defined by a pair of ideals. What is this?	24
Pôsters	27
Alex Pereira da Silva	
A Study of Dimension Theory Applied to Dynamical Systems	29
Camila Aparecida Benedito Rodrigues	
An estimative for the number of limit cycles of some discontinuous systems with two zones	29
Liliam Carsava Merighe	
On a Theorem of Makar-Limanov	30
Maycon Sullivan Santos Araújo	
Elliptic equations with critical nonlinearity	30
Paulo Nicanor Seminario Huertas	
A well posedness result and existence of the global attractors for nonlinear viscoelastic equations with memory	30
Renan Maneli Mezabarba	
Function spaces, selection principles and bornologies	31
Roberto Daniel Torrealba Fernandez	
A New Kind of Matrix Representation for Polynomials and an Application in the Computing of Gröbner Bases	31

Yony Raúl Santaria Leuyacc	
Elliptic partial equations with critical exponential growth	31
Lista de e-mails	33



IV Workshop de Teses e Dissertações em Matemática

Instituto de Ciências Matemáticas e de Computação – USP São Carlos

Palestra de Abertura

As desigualdades de Bohnenblust-Hille e Hardy-Littlewood

Daniel Marinho Pellegrino

Universidade Federal da Paraíba, Brasil

A desigualdade de Bohnenblust-Hille, demonstrada em 1931, no *Annals of Mathematics*, garante que para cada inteiro positivo m existe uma constante $C_m \geq 1$ tal que

$$\left(\sum_{i_1, \dots, i_m=1}^N |T(e_{i_1}, \dots, e_{i_m})|^{\frac{2m}{m+1}} \right)^{\frac{m+1}{2m}} \leq C_m \|T\|,$$

para todos inteiros positivos N e todas formas m -lineares T definidas em $\ell_\infty^N \times \dots \times \ell_\infty^N$. Embora tenha sido concebida como ferramenta para o estudo de problemas relacionados a séries de Dirichlet, atualmente a desigualdade de Bohnenblust-Hille tem aplicações em diferentes áreas da matemática e até mesmo em Teoria da Informação Quântica. Curiosamente, em tais aplicações, o controle das constantes C_m tem papel central. Apresentaremos resultados recentes que mostram que, em forte contraste com as previsões dos últimos 80 anos, as constantes C_m têm um crescimento muito lento.

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Palestras

Topological classification of quadratic vector fields with semi-elemental saddle-nodes

Alex Carlucci Rezende

Planar quadratic differential systems occur in many areas of applied mathematics. Although more than one thousand papers have been written on these systems, a complete understanding of this family is still missing. One of the goals of recent researchers is the topological classification of quadratic systems. As this attempt is not possible in the whole class due to the large number of parameters (twelve, but, after affine transformations and time rescaling, we arrive at families with five parameters, which is still a large number), many subclasses are considered and studied. In this talk we present the study a subfamilies of quadratic systems possessing a finite semi-elemental saddle-node and an infinite semi-elemental saddle-node formed by the collision of an infinite saddle with an infinite node. The bifurcation diagram for this family is tridimensional and yields 369 topologically distinct phase portraits. Invariant polynomials are used to construct the bifurcation sets and the phase portraits are represented on the Poincaré disk. The bifurcation sets are the union of algebraic surfaces and surfaces whose presence was detected numerically. This is a joint work with Joan Carles Artés (UAB-Barcelona).

Acknowledgements: We would like to thank CAPES-PROEX for the financial support.

Curves on a timelike surface

Andrea Sacramento

Our aim is to introduce the notion of pseudo-spherical evolutes of curves on a timelike surface in three dimensional Minkowski space. We investigate the singularities and geometric properties of pseudo-spherical evolutes of curves on a timelike surface. Furthermore, we investigate the relation of the de Sitter (hyperbolic) evolute of a spacelike curve in S_1^2 with the lightlike surface along the curve in \mathbb{R}_1^3 .

On the topology of Morin singularities

Camila Mariana Ruiz

As remarked in [1], it is well known that there is a deep relation between the topology of a manifold M and the topology of the critical locus of maps defined on M . A good example of this fact is Morse Theory which gives the Euler characteristics of a compact manifold M in terms of the Morse indices of the critical points of a Morse function $f : M \rightarrow \mathbb{R}$ defined on M :

$$\chi(M) = \sum_{i=1}^n (-1)^{\lambda(p_i)}$$

R. Thom [2] proved that the Euler characteristic $\chi(M)$ of a compact manifold M of dimension at least 2 has the same parity as the number of cusps of a generic map $f : M \rightarrow \mathbb{R}^2$: $\chi(M) = \#K(f) \pmod{2}$. Later H. I. Levine [3] improved this result giving an equality relating $\chi(M)$ and the critical set of f . In [4], T. Fukuda generalized R. Thom's result to Morin maps $f : M \rightarrow \mathbb{R}^n$ when $\dim M \geq n$. Furthermore if f has only fold points (i.e., singularities of type A_1), then T. Fukuda gave an equality relating $\chi(M)$ to the critical set of f . In [1], N. Dutertre and T. Fukui use Viro's integral calculus [7] to study the topology of stable maps. They also discuss several applications to Morin maps. In particular, in Theorem 6.2 [1], they

give an equality relating the Euler characteristic of a compact manifold M and the Euler characteristic of the singular sets of a Morin map defined on M .

In this work, we present results of T. Fukuda and N. Dutertre-T. Fukui on the topology of Morin maps. In particular, we give an alternative proof for Theorem 6.2 [1] when $N = \mathbb{R}^n$, using not Viro's integral calculus, but Morse Theory for manifolds with boundary.

Acknowledgements: We would like to thanks CNPQ by financial support.

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Hausdorff dimension of quasi-arcs

Carlos Alberto Siqueira Lima

Consider the Julia set $J(c)$ of $z^q + c$. Concerning its Hausdorff dimension, Ruelle (1982) proved the following dichotomy:

Theorem. *Either $HD(J(c)) > 1$ and $J(c)$ is quasi-circle, or $c = 0$ and J is a round circle.*

The original idea really belongs to Bowen (1979).

Motivated by Sullivan's dictionary, Bullett and Penrose (2001) indicated some analogies relating the dynamics of holomorphic correspondences, Kleinian groups, and rational maps. This talk provides new tools to study the correspondence $z^r + c$ when r is rational, adding a new line to this dictionary: we show that its Julia set at $c = 0$ enjoy quite the same dichotomy stated above.

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On the behavior of partially hyperbolic teenagers

Gabriel Ponce

Chaos theory is one of the main topics studied in smooth dynamical systems. Given an ambient space M and a function $f : M \rightarrow M$, the study of the behavior of orbits $\{f^n(x)\}_{n \in \mathbb{Z}}$ in terms of topological, metric, statistical, or other classes of properties constitutes the study and classification of the *dynamics* of f . The study of the degree of unpredictability of a system $f : M \rightarrow M$ is usually called chaos theory, and the classification of the statistical behavior in terms of probability measures is what we call ergodic theory. The different degrees of chaos in terms of measure are distinguished by an hierarchy of *ergodic properties*. Each ergodic property gives an information of how fast the system mix different sets along the time. The strongest ergodic property, that is, the stronger degree of chaos is given by the *Bernoulli property*.

In this talk we will study a family of diffeomorphisms called *partially hyperbolic diffeomorphisms* acting on $M = \mathbb{T}^3$ and we will prove that, like a generic teenager, almost all diffeomorphisms of this family are extremely chaotic, namely they have the Bernoulli property. Formally speaking, in a joint work with R. Varão and A. Tahzibi we proved the following:

Theorem: [1] For any $1 < r \leq \infty$, a C^r -open and dense set of $C^{1+\alpha}$ partially hyperbolic diffeomorphism of \mathbb{T}^3 are Bernoulli.

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Qualitative properties of impulsive dissipative semidynamical systems

Ginnara Mexia Souto

Our goal in this work is to approach the theory of dissipative impulsive semidynamical systems. We consider different types of dissipativity as point, compact, local and bounded. Moreover, We present results that guarantee the existence of maximal compact invariant for the system of impulsive semidynamical dissipation.

Acknowledgements: We would like to thanks FAPESP by financial support.

Global solvability of involutive systems

Giuliano Angelo Zugliani

We are interested in studying an involutive system of partial differential equations associated with a closed non-exact 1-form b defined on a closed and orientable surface of genus greater than 1.

Here we present a condition about the sublevels and the superlevels of a primitive of b in a certain covering space which implies that the system is not globally solvable.

We also make some particular constructions of globally solvable systems that motivate the equivalence between the global solvability and the necessary condition, for two cases involving 1-forms of the Morse type, namely, when the surface is the bitorus or when b is generic.

This PhD thesis had Prof. Sérgio Luís Zani (ICMC-USP) and Prof. Alberto Parmeggiani (Università di Bologna) as co-advisors.

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Classification of singular levels and Morse Bott integrable systems on surfaces

Ingrid Sofia Meza Sarmiento

We construct a complete topological invariant for Morse Bott integrable systems on compact surface Σ . These systems are a generalization of Hamiltonian systems with one degree on Σ . We classify up to homeomorphisms closed curves and eights of saddle points on orientable closed surfaces. The tool that we use is the Reeb's graph of the Hamiltonian f and the mentioned classification.

Some previous references: [1], [2], [3] and [4].

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Non-degenerate ideals in the ring of polynomials

Jorge Alberto Coripaco Huarcaya

Kouchnirenko in 1976 shows a formula to compute the Milnor number of isolated singularity germs of functions in terms of the Newton polyhedron of the germ. Bivia-Ausina, Fukui and

Saia in 2002 characterized a class of finite codimension ideals in the ring of formal power series which satisfy a Newton non degeneracy condition, moreover they showed how to compute the Hilbert Samuel multiplicity of such ideals in term of a convenient Newton polyhedron. On the other side Kouchnirenko shows a formula to compute the Milnor number of Newton non degenerate polynomials in terms of its Newton polyhedron. The main purpose of this project is to develop a study about the Newton non degeneracy condition for polynomial maps $F : \mathbb{C}^n \rightarrow \mathbb{C}^n$, with $F^{-1}(0)$ finite and methods to compute the multiplicity in terms of convenient Newton polyhedra, following the ideas of Kouchnirenko.

Rigorous Results on the Particle Spectrum of Lattice Quantum Chromodynamics Models in the Strong Coupling Regime

José Carlos Valencia Alvites

Our research project aims at obtaining rigorous results on the spectral properties of some important models in particle physics. Namely, we want to validate the two-particle (bound state) spectral results, recently obtained by our group, beyond the so called ladder approximation. We work with a local gauge-invariant $SU(3)$ Quantum Chromodynamics (QCD) model, with two-flavor quarks. Using 4×4 Dirac spin matrices, the model is defined on the discrete lattice Euclidean space-time with $3 + 1$ dimensions. Using an adapted Feynman-Kac formula, an imaginary-time functional integral formulation with Wilson's action is employed, in the strong coupling regime, i.e. taking a small hopping parameter $0 < \kappa \ll 1$, and much smaller plaquette coupling $0 < \beta \ll \kappa$. To determine the energy-momentum (particle) spectrum, a temporal hyperplane decoupling expansion is used, together with spectral and complex analysis techniques. Functional analytical methods are then applied to control perturbations and extend the spectral results beyond the ladder approximation. In doing our analysis, some results regarding the computation of moments of the Haar measure of the gauge $SU(3)$ group are also fundamental.

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Surfaces in 4-space from the affine differential geometry viewpoint

Luis Florial Espinoza Sánchez

In this work, we study locally strictly convex surfaces from the affine differential viewpoint. We introduce a family of affine metrics on a locally strictly convex surface M in affine 4-space. Then, we define the symmetric and antisymmetric equiaffine planes associated with each metric. We show that if M is immersed in a locally strictly convex hyperquadric, then the symmetric and the antisymmetric planes coincide and contain the affine normal to the hyperquadric. In particular, any surface immersed in a locally strictly convex hyperquadric is affine semiumbilical with respect to the symmetric or antisymmetric equiaffine planes. More generally, by using the metric of the transversal vector field on M we introduce the affine normal plane and the families of the affine distance and height functions on M . We show that the singularities of the family of the affine height functions appear at directions on the affine normal plane and the singularities of the family of the affine distance functions appear at points on the affine normal plane and the affine focal points correspond as degenerate singularities of the family of affine distance functions. Moreover we show that if M is immersed in a locally strictly convex hypersurface, then the affine normal plane contains the affine normal vector field to the hypersurface. Finally, we conclude that any surface immersed in a locally strictly convex hypersphere is affine semiumbilical.

Bouquet of spheres for real Milnor fibrations

Maria Amelia Hohlenwerger

In his book “Singular points of complex hypersurfaces”, John Milnor proved that for a holomorphic function germ with an isolated singularity at the origin, the Milnor fiber has the homotopy type of a bouquet of spheres. In this talk, we will show that such bouquet structure is no longer true in general on the real settings and we will give sufficient conditions under which the bouquet structure holds, up to homotopy.

Acknowledgements: We would like to thanks FAPESP by financial support.

Projection of space curves and their contact with circles

Mostafa Salarinoghabi

Let $\gamma : I \rightarrow \mathbb{R}^3$ be a regular space curve and α_v be its orthogonal projection along a unit direction $v \in S^2$. The curve α_v belongs to the plane $T_v S^2$. Its evolute is the bifurcation set of the family of distance squared function $D_v(t, x) = \|\alpha_v(t) - x\|^2$, $t \in I$, $x \in T_v S^2$.

Representing homotopy classes by maps with certain minimality root properties

Northon Canevari Leme Penteadó

The propose of this work is to represent the elements of $[S, S^2 \vee S^1]$ by maps with some minimality root properties, where $S = S^2$ or $S = T^2$.

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Global solvability of vector fields on the torus

Rafael Borro Gonzalez

A (smooth) *vector field* on the $N + 1$ -torus $\mathbb{T}^{N+1} \simeq \mathbb{R}^{N+1}/2\pi\mathbb{Z}^{N+1}$ is a \mathbb{C} -linear map

$$L : \mathcal{C}^\infty(\mathbb{T}^{N+1}) \rightarrow \mathcal{C}^\infty(\mathbb{T}^{N+1})$$

which satisfies the Leibniz rule

$$L(fg) = fL(g) + gL(f).$$

A vector field is said to be *globally solvable* when its range is closed.

We first discuss global solvability for the vector fields

$$\frac{\partial}{\partial t} + \sum_{j=1}^N c_j(t) \frac{\partial}{\partial x_j}, \tag{1}$$

where $c_j(t) = a_j(t) + ib_j(t)$, with $a_j, b_j \in C^\infty(\mathbb{T}^1, \mathbb{R})$. We set $a_0 = (2\pi)^{-1} \int_0^{2\pi} a(t)dt$ and $b_0 = (2\pi)^{-1} \int_0^{2\pi} b(t)dt$. The following facts are related to the global solvability of (1): *i*) diophantine conditions for the numbers a_0 and b_0 ; *ii*) connectedness of the sublevel sets of the functions $\sum_{j=0}^N \xi_j \int_0^t b_j(s)ds$, $\xi_j \in \mathbb{Z}$; *iii*) the linear dependence of the functions $b_\ell(t)$ and $b_k(t)$, $\ell, k \in \{1, \dots, N\}$; and *iv*) the asymptotic behavior of certain integrals (Laplace's method for integrals).

We also discuss global solvability for the vector fields

$$\frac{\partial}{\partial t} + c(x_1) \left(\frac{\partial}{\partial x_1} + \lambda \frac{\partial}{\partial x_2} \right), \quad (2)$$

where $c(x_1) = a(x_1) + ib(x_1)$, $a, b \in C^\infty(\mathbb{T}^1, \mathbb{R})$, and $\lambda \in \mathbb{R}$.

The global solvability of (2) is related to Liouville numbers and to the interplay between the orders of vanishing of a and b at a common zero. The most interesting case occurs when $c^{-1}(0) \neq \emptyset$ and c has only zeros of finite order. In this case, it is worth pointing out that the range of (2) has not finite codimension.

Acknowledgements: We would like to thanks FAPESP by financial support.

Multitoric surfaces, Euler obstruction and applications

Thaís Maria Dalbello

In this work we study surfaces with the property that their irreducible components are toric surfaces. In particular, we present a formula to compute the local Euler obstruction of such surfaces. As an application of this formula we compute the local Euler obstruction for some families of determinantal surfaces. Furthermore, we define the vanishing Euler characteristic of a normal toric surface X_σ , we give a formula to compute it, and we relate this number with the second polar multiplicity of X_σ . We also present a formula for the Euler obstruction of a function $f : X_\sigma \rightarrow \mathbb{C}$ and for the Brasselet number of it. As an application of this result we compute the Euler obstruction of a type of polynomial on a family of determinantal surfaces.

Formal Local Cohomology defined by a pair of ideals. What is this?

Thiago Henrique de Freitas

In this work we introduce a generalization of the formal local cohomology module which will call the "Formal Local Cohomology module defined by a pair of ideals". For this we will use a recent generalization of an important tool in commutative algebra and algebraic geometry that is the concept of local cohomology. We will compare the results and important properties obtained in our context with known results in local cohomology and ordinary formal local cohomology.

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Pôsters

A Study of Dimension Theory Applied to Dynamical Systems

Alex Pereira da Silva

In the context of dynamical systems theory, the study of global attractors is essential and can be treated in many ways. Here, we study imbeddings of global attractors in finite dimensional spaces. To be more precise, under which assumptions about the global attractor it is possible to guarantee that it can be projected injectively over a subset of a finite dimensional vector space. Once this is done, we can ensure that the asymptotic dynamics of the system (which can be defined in a Banach space of infinite dimension) actually lies at a space of finite dimension.

This approach is by means of the dimension theory and encompasses the notions of topological dimension, Hausdorff dimension and fractal dimension in metric spaces as well as methods to estimate them. Such methods are based on the spectral decomposition of linear operators and the construction of exponential attractors for semigroup.

Acknowledgements: We would like to thanks FAPESP by financial support.

An estimative for the number of limit cycles of some discontinuous systems with two zones

Camila Aparecida Benedito Rodrigues

The number of limit cycles which bifurcates from periodic orbits of differential systems with centers has been extensively studied recently using many distinct tools. This problem was proposed by Hilbert in 1900 and it is a difficult problem so only particular families of such systems were considered. Llibre and Mereu (2011) have applied the continuous *averaging* to study the maximum number of limit cycles that can bifurcate from periodic orbits of the linear center $\dot{x} = y$, $\dot{y} = -x$, perturbed inside the following class of generalized polynomial differential systems of type Kukles:

$$\begin{cases} \dot{x} = y \\ \dot{y} = -x - \sum_{k \geq 1} \varepsilon^k (f_{n_1}^k(x) + g_{n_2}^k(x)y + h_{n_3}^k(x)y^2 + d_0^k y^3) \end{cases} \quad (3)$$

where $f_{n_1}^k(x)$, $g_{n_2}^k(x)$, and $h_{n_3}^k(x)$ have degree n_1 , n_2 and n_3 respectively, for all k and $d_0^k \neq 0$ is a real number, ε is a small parameter. They proved that the maximum number of limit cycles of (3), with $k = 1$, that bifurcate of the periodic orbits is

$$\max \left\{ \left[\frac{n_2}{2} \right], 1 \right\},$$

where $[.]$ denotes the integer part of the number.

In this talk we shall discuss about a generalization of this result to a special class of discontinuous system having a line of discontinuity, namely, we investigated the number of limit cycles that can bifurcate from the Fillipov's system

$$Z(x, y) = \begin{cases} X_1(x, y) & \text{if } h(x, y) > 0, \\ X_2(x, y) & \text{if } h(x, y) < 0. \end{cases} \quad (4)$$

where $h(x, y) = y - \tan(\alpha)x$,

$$X_j(x, y) = \begin{pmatrix} y \\ -x - \varepsilon (f_{n_1}^j(x) + g_{n_2}^j(x)y + h_{n_3}^j(x)y^2 + d_0^j y^3) \end{pmatrix},$$

$f_{n_1}^j(x)$, $g_{n_2}^j(x)$ and $h_{n_3}^j(x)$ are polynomials of degrees n_1 , n_2 and n_3 respectively, d_0^j is a nonzero constant for $j = 1, 2$ and $\alpha \in (-\frac{\pi}{2}, \frac{\pi}{2})$.

On a Theorem of Makar-Limanov

Liliam Carsava Merighe

In the context of locally nilpotent derivations we have some definitions, principles and important results. Our propose is this poster is to prove one of the foundational facts about locally nilpotent derivations of polynomial rings which is the following Theorem, due to Makar-Limanov.

Makar-Limanov's Theorem: Suppose $D \in \text{LND}(B)$ is irreducible, where $B = k[x_1, \dots, x_n]$. Let f_1, \dots, f_{n-1} be $n - 1$ algebraically independent elements of $\ker D$, and set $\mathbf{f} = (f_1, \dots, f_{n-1})$. Then there exists $a \in \ker D$ such that $\Delta_{\mathbf{f}} = aD$. In particular, $\Delta_{\mathbf{f}} \in \text{LND}(B)$.

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Elliptic equations with critical nonlinearity

Maycon Sullivan Santos Araújo

The goal of this work is to investigate the existence of multiple solutions of the critical superlinear problem

$$\begin{cases} -\Delta u = \lambda u + u_+^{2^*-1} + f(x) & , \text{ in } \Omega \\ u = 0 & , \text{ on } \partial\Omega \end{cases} \quad (5)$$

where $2^* = \frac{2N}{N-2}$, $N \geq 3$, is the critical Sobolev exponent and $\lambda > \lambda_1$ is a constant with $\lambda \neq \lambda_k$ $\forall k \in \mathbb{N}$ where $\lambda_1 < \lambda_2 \leq \dots \leq \lambda_k \leq \dots$ are the eigenvalues of the Laplacian. For this, we studied the article [1] in order to understand and detail the proofs contained therein.

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A well posedness result and existence of the global attractors for nonlinear viscoelastic equations with memory

Paulo Nicanor Seminario Huertas

In this work, we establish an existence, uniqueness and continuous dependence result for the weak solutions to the nonlinear viscoelastic equation with hereditary memory on a bounded three-dimensional domain, which has the following form

$$|\partial_t u|^\rho \partial_{tt} u - \Delta \partial_{tt} u + \gamma(-\Delta)^\theta \partial_t u - \alpha \Delta u + \int_0^\infty \mu(s) \Delta u(t-s) ds + f(u) = h$$

with Dirichlet boundary conditions and ρ belongs to the interval $[0, 4]$. Also, we studied the asymptotic properties of the semigroup $S(t)$ arisen above.

Such class of problems were studied by several authors since 2001. For the existence of solutions, we continue the work of Conti, Marchini and Pata [2] and in order to prove the existence of global attractor, we generalize the paper of Araujo and Ma To Fu [1] with a slightly weaker damping.

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Function spaces, selection principles and bornologies

Renan Maneli Mezabarba

Let X be a Tychonoff space and consider its hyperspace $C_p(X)$, the space of the continuous real functions on X with the topology of the pointwise convergence. In [1], with the use of bornologies, we generalize some results concerning convergence properties of $C_p(X)$ for a class of topologies on $C(X)$, that includes the pointwise convergence topology as well as the compact open topology. In particular, we obtain necessary and sufficient conditions to the space $C(X)$ to be productively countably tight with the compact open topology.

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A New Kind of Matrix Representation for Polynomials and an Application in the Computing of Gröbner Bases

Roberto Daniel Torrealba Fernandez

In this work we introduce a new kind of matrix representation for polynomials in one, two and n indeterminates. For one and two indeterminates we define the addition and multiplication of polynomials in term of submatrices of the matrix representation, in the case of n indeterminates the operations can be defined by induction. With this representation we can easily identify the leading monomial of a polynomial in more than one indeterminates, independently of the ordering. We also give a criterion for the divisibility of monomials in order to compute Gröbner Bases. We use this criterion to reduce a polynomial, and we can visualize the reduction process, this happens when the numbers of zeros of the first row of the matrix representation of the given polynomial increases from left to right on the reduced polynomial.

Elliptic partial equations with critical exponential growth

Yony Raúl Santaria Leuyacc

In this work we study the existence and non-existence of non-trivial solutions to the following elliptic problem:

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

where Ω is a bounded and smooth domain in \mathbb{R}^2 and f possesses critical exponential growth, this means exist $\alpha_0 > 0$ such that

$$\lim_{|t| \rightarrow \infty} \frac{|f(x, t)|}{\exp(\alpha t^2)} = \begin{cases} 0, & \text{uniformly in } \bar{\Omega}, \forall \alpha > \alpha_0, \\ +\infty, & \text{uniformly in } \bar{\Omega}, \forall 0 < \alpha < \alpha_0. \end{cases}$$

The existence results are proved by using variational methods and the Trudinger-Moser inequalities. The non-existence result is restricted to the case of positive radial solutions and $\Omega = B_1(0)$. The proof uses techniques of the theory of ordinary differential equations.



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