ICMC SUMMER MEETING on Differential Equations

2018 Chapter

5-7 february 2018 | São Carlos SP, Brazil

summer.icmc.usp.br

Celebrating the 75th birthday of Shui-Nee Chow

Scientific Committee

José Arrieta - *Universidad Complutense de Madrid/Spain*

Tomás Caraballo - *Universidad de Sevilla/Spain*

Alexandre Nolasco de Carvalho - *USP/Brazil*

Djairo Guedes de Figueiredo - *UNICAMP/Brazil*

Kening Lu - *Brigham Young University/USA*

John Mallet-Paret - *Brown University/USA*

Geneviève Raugel - *Université Paris-Sud/France*

Hildebrando Munhoz Rodrigues - *USP/Brazil*

Wenxian Shen - *Auburn University/USA*

Yingfei Yi - *University of Alberta/Canada and JLU/China*

Haomin Zhou - *Georgia Institute of Technology/USA*

List of sessions

Computational dynamics

Conservation laws and transport equations

Dispersive equations

Elliptic equations

Fluid dynamics

Linear equations

Nonlinear dynamical systems

Ordinary and functional differential equations

CAPES CNPq FAPESP USP ICMC USP SÃO CARLOS INCTMat

Welcome

It is a pleasure to welcome you to the *ICMC Summer Meeting on Differential Equations - 2018 Chapter* and to São Carlos. We wish you a pleasant stay and that you enjoy the meeting.

Executive committee

Alexandre N. de Carvalho (USP/Brazil)

Hildebrando M. Rodrigues (USP/Brazil)

Márcia C. A. B. Federson (USP/Brazil)

Ma To Fu (USP/Brazil)

Sérgio H. Monari Soares (USP/Brazil)

Organizing committee

Ederson M. dos Santos (USP/Brazil)

Everaldo de Mello Bonotto (USP/Brazi)

Paulo L. Dattori da Silva (USP/Brazil)

Scientific committee

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Djairo G. de Figueiredo (UNICAMP/Brazil)

Geneviève Raugel (Université Paris-Sud/France)

Haomin Zhou (Georgia Institute of Technology/USA)

Hildebrando Munhoz Rodrigues (USP/Brazil)

John Mallet-Paret (Brown University/USA)

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Kening Lu (Brigham Young University/USA)

Tomás Caraballo (Universidad de Sevilla/Spain)

Wenxian Shen (Auburn University/USA)

Yingfei Yi (University of Alberta/Canada and JLU/China)

Session Organizers

Gabriela Planas (UNICAMP/Brazil) & Wladimir Neves (UFRJ/Brazil): Special Session on Conservation Laws and Transport Equations & Fluid Dynamics

Márcia A. G. Scialom & Mahendra Panthee (UNICAMP/Brazil): Special Session on Dispersive Equations

Claudianor O. Alves (UFCG/Brazil): Special Session on Elliptic Equations

Paulo L. Dattori da Silva (USP/Brazil): Special Session on Linear Equations

Juliana F.S. Pimentel (UFABC/Brazil) & Marcio F. Gameiro (USP/Brazil): Special Session on Nonlinear Dynamical Systems & Computational Dynamics

Jaqueline Godoy Mesquita (UnB/Brazil): Special Session on Ordinary and Functional Differential Equations

Raquel Lehrer (UNIOESTE/Brazil): Poster Session

Address

ICMC Summer Meeting on Differential Equations - 2018 Chapter
Instituto de Ciências Matemáticas e de Computação
Universidade de São Paulo
Avenida Trabalhador São-carlense, 400
CEP: 13566-590 - São Carlos - SP
FAX: +55 (16) 3371-2238
e-mail: summer@icmc.usp.br

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

2018 Chapter

Maps

Nome/Name: _____

Hosted in São Sarlos at the hotel: _____

Address: _____

Phone number: _____

Contact: _____

Tipo sanguíneo / Blood type: _____

Tomando medicação/Taking medication: _____

Alérgico a medicamentos / Alergic to medication: _____

Doença crônica / Chronic disease: _____

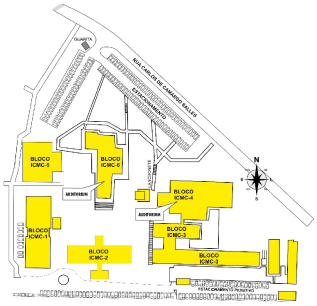
USEFUL NUMBERS

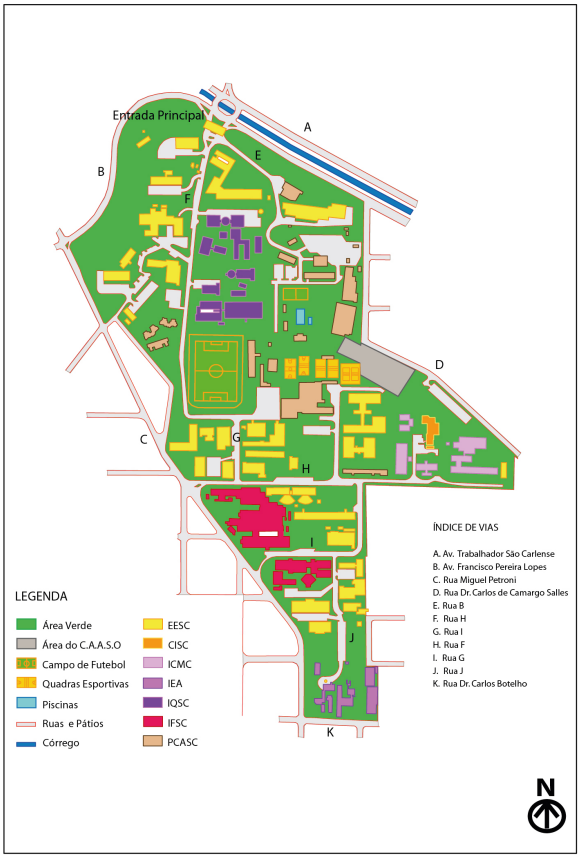
3373-9700	ICMC-USP
3373-9112	Campus Security Staff
190	Police Dept.
192	Medical Emergency
193	Fire Dept. and Rescue
0800-560159	National Courier Service
3371-2171	Local Post Office
3415-6005	Taxi-Cab Co.

www.visitesaocarlos.com.br/taxis.htm
(other Taxi-Cab Companies)

ENTRANCES AND EXITS OF THE CAMPUS

1. ICMC entrance
2. Main entrance
3. Observatory´s entrance
4. Physic´s institute entrance
5. Physic´s institute entrance





HOTÉIS - HOTELS

H1. Indaiá Hotel
R. Jacinto Favoreto, 351

H2. Atlantic Inn Residence
R. Salomão Dibbo, 321

H3. Indaiá Hotel Residence
R. Jacinto Favoretto, 782

H4. Parisi Hotel
Av. São Carlos, 3.163

H5. Hotel Anacã
Av. São Carlos, 2.690

H6. Hotel Ypê
Av. Dr. Carlos Botelho, 2.060

H7. Central Park Apart Hotel
Av. Francisco Pereira Lopes, 2.600

H8. Hotel Acaccio
Av. São Carlos, 1.981

H9. Atlantic Inn Royale
R. Conde do Pinhal, 1.630

H10. Hotel Caiçara
R. Conde do Pinhal, 2.217

H11. Hotel Othon Suítes
R. Cons João Alfredo, 77

H12. Ibis Hotel
R. Passeio dos Ipês, 140

BRAZILIAN SOUVENIRS

1. Papelaria CAASO (USP)
2. Praça XV de novembro (Sunday after 15h)
3. Duda Maria
   rua José Bonifácio, 1177 - 3307.2402

RECOMMENDED BAR, RESTAURANTS AND PIZZERIAS

R1. Restaurante Kallas
Av. São Carlos, 2784 - 3364.6362 - LUNCH/DINNER

R2. Quase 2 Restaurante e Hamburgueria
Av. São Carlos, 2796 - 3372.7240 - LUNCH and FAST FOOD at night

R3. Roda Chopp Restaurante
Av. São Carlos, 2603 - 3372.2343 - LUNCH ONLY

R4. Restaurante La Salute
R. Cons. João Alfredo, 47 - 3116.4939 - VEGETARIAN FOOD - LUNCH ONLY

R5. Casa do Café Restaurante
R. Riachuelo, 1201 - 3371.3033 - LUNCH/DINNER

R6. Cantina Ciao Bello
R. Riachuelo, 1.191 - 3371.4174 - LUNCH ONLY

R7. Restaurante Curinga
Av. Trabalhador Sãocarlense, 650 - 3413.3777 - LUNCH ONLY

R8. Barone Restaurante
Av. Dr. Carlos Botelho, 1.671 - 3412.8586 - LUNCH/DINNER

R9. Restaurante Mosaico
R. Aquidaban, 1.342 - 3371.4474 - LUNCH/DINNER

R10. Yo Konno
R. Aquidaban, 1368 - 3413.1666

R11. YouOki Culinária Asiática
R. Aquidaban, 1390 - 3415.2848 - ASIAN FOOD - LUNCH/DINNER

R12. Restaurante Paraíso
R. Dna. Maria Jacinta, 340 - 3376.6424 - LUNCH ONLY

R13. Habbib´s
Av. Trabalhador Sãocarlense, 620 - 3371.2223 - 24 hours

R14. Bom Pedaço Pizza & Bar
Av. Trabalhador Sãocarlense, 584 - 3371.3696 - DINNER ONLY

R15. La Villa Restaurante e Lanchonete
R. Quinze de Novembro, 1330 - 3376.2843 - LUNCH/DINNER
Tip: Special brazilian food (Feijoada) and music at Saturdays

R16. Amici Pizza & Cibo
R. Quinze de Novembro, 1289 - 3371.6463 - DINNER ONLY

R17. West Brothers Chopp & Culinária
Av. Trabalhador Sãocarlense, 671 - 3415.5717 - DINNER ONLY

R18. Yasan Restaurante/Bar
Av. Dr. Carlos Botelho, 1768 - 3307.1165 - LUNCH/DINNER

R19. King Fish Restaurante
Av. Trabalhador Sãocarlense, 25 - 3412.7400 - DINNER ONLY

R20. Restaurante Picanha na Tábua
Av. Francisco Pereira Lopes, 2520 - 3361.1453 - LUNCH/DINNER

R21. McDonald´s
Av. São Carlos, 3134 - 3374.7402 - 24 hours

R22. Seo Gera
R. Episcopal, 2442 - 3372.1051 - DINNER ONLY

R23. Trembão Burger & Grill
Av. São Carlos, 3055 - 3307.6189 - DINNER ONLY

R24. Restaurante Mamãe Natureza
R. Cap. Adão Pereira Cabral, 457 - 3374.2653 - VEGETARIAN FOOD - LUNCH ONLY

R25. China in Box
Av. São Carlos, 3030 - 3376.1221 - LUNCH/DINNER

R26. Restaurante Panela
R. Dr. Orlando Damiano, 2157 - 3371.4157 - LUNCH/DINNER

R27. Casa do Filé Restaurante
R. Nove de Julho, 1688 - 3307.2412 - DINNER ONLY

R28. Cabanha Steakhouse & Bar
R. Episcopal, 1661 - 3364.3067 - LUNCH/DINNER

R29. Restaurante Frei Damião
R. Nove de Julho, 1606 - 3416.8133 - LUNCH ONLY

R30. Restaurante Frei Damião
R. Quinza de Novembro, 1447 - 3416-3276 - LUNCH ONLY

R31. Don Raffaele Pizze & Ristorante
R. Marechal Deodoro, 1758 - 3371.1478 - ONLY DINNER

R32. Subway
Av. São Carlos, 2911 - 3416.4000 - 24 hours

R33. Kalil Cozinha Árabe
R. Dr. Carlos Botelho, 1737 - 3372.1696
ARABIC AND VEGETARIAN FOOD - LUNCH/DINNER

R34. Café Sete - Café Gastrobar
R. Sete de Setembro, 1447 - 3415.1026 - DINNER ONLY

R35. Churrascaria Tabajara
Av. São Carlos, 3677 - 3361.4282 - STEAKHOUSE - LUNCH/DINNER

R36. Churrascaria Trevo
Av. Prof. Luis Augusto de Oliveira, 385
(extension of the Av. São Carlos) - 3361.3052 - STEAKHOUSE - LUNCH/DINNER

R37. Restaurante e Buffet Cantos e Contos
Rua Major José Inácio, 2211 - 3372.6661

R38. Restaurante Sushi Ya-San
Rua Tiradentes, 128 - 3307.1165 - JAPANESE FOOD - LUNCH/DINNER

R39. Restaurante Zettai
Rua Marechal Deodoro, 1846 - 3416.5140 - JAPANESE FOOD - DINNER ONLY

R40. Restaurante Niray
Rua Major José Inácio, 2273 - 3415-6505 - JAPENESE FOOD - LUNCH/DINNER

R41. Restaurante e Choperia Rola Papo
Rua Major José Inácio, 2270 - 3412-6757 - DINNER ONLY

R42. Água Doce Cachaçaria
Rua 9 de julho, 1625 - 3376.2077 - LUNCH/DINNER

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ICMC USP SÃO CARLOS


Rodovia Washington Luiz
UFSCAR
Churrascaria Trevo (R36)
Churrascaria Tabajara (R35)
USP (campus 2)
Café Tropical
Shopping Center
Ibis Hotel (H12)
Av. Comendador
Alfredo Maffei
USP - São Carlos
Campus 1
Al. dos Crisântemos
R. Alvarenga Peixoto
Al. das Hortências
Av. das Azaléias
Av. Trabalhador Sãocarlense
Al. das Crisandálias
R. Antonio Blanco
R. Dna. Alexandrina
R. São Joaquim
Av. Prof. Luis A. Oliveira
R. Salomão Dibbo
R. 9 de Julho
R. Cezar Ricomi
Rodoviária
(Bus Station)
R. Miguel Petrone
R. Achille Bassi
R. Jacinto Favoretto
Rua Dr. Carlos de Camargo Salles
Bank of Brazil AG 6845-4
11h00m to 16h00m
MON to FRI
PAPELARIA
CAASO
PRAÇA
BIBLIOTECA
ALOJAMENTO
ICMC-USP
(ZOOM UP AT THE BACK OF THIS PAGE)
R. Episcopal
R. Adolfo Cattani
R. Alfredo Lopes
R. Conselheiro João Alfredo
R. Orlando Damiano
R. Dna. Maria Jacinta
R. Tiradentes
R. Dr. Serafim Vieira de Almeida
R. 28 de Setembro
Santa Casa
(Hospital)
R. Princesa Isabel
R. Maestro João Seppe
R. Paulino Botelho de Abreu Sampaio
R. Paulino Botelho A. Sampaio
R. Cap. Adão Pereira de Souza Cabral
Praça
XV de
Novembro
Av. Dr. Carlos Botelho
Av. São Carlos
R. 15 de Novembro
R. José Bonifácio
R. São Sebastião
R. Visconde de Inhaúma
R. Aquidaban
Escola
Dr. Álvaro
Guião
R. Padre Teixeira
R. Riachuelo
R. Marechal Deodoro
R. 7 de Setembro
Praça
dos
Pombos
R. Major José Inácio
R. Conde do Pinhal
Catedral
Praça
da
Catedral
Av. Comendador Alfredo Maffei
Centro
Portaria "A"
Portaria "B"
Portaria "C"
Portaria "D"
Campus Entrances
Money Exchange
Hotel
ATM
Drugstore
Supermarket-Grocery
Post Office
Bus Station
Bakery-Coffee-Snack bar
Restaurant
Other restaurant or Pizzeria
Açaí (Brazilian Ice Cream)
Bar Restaurant

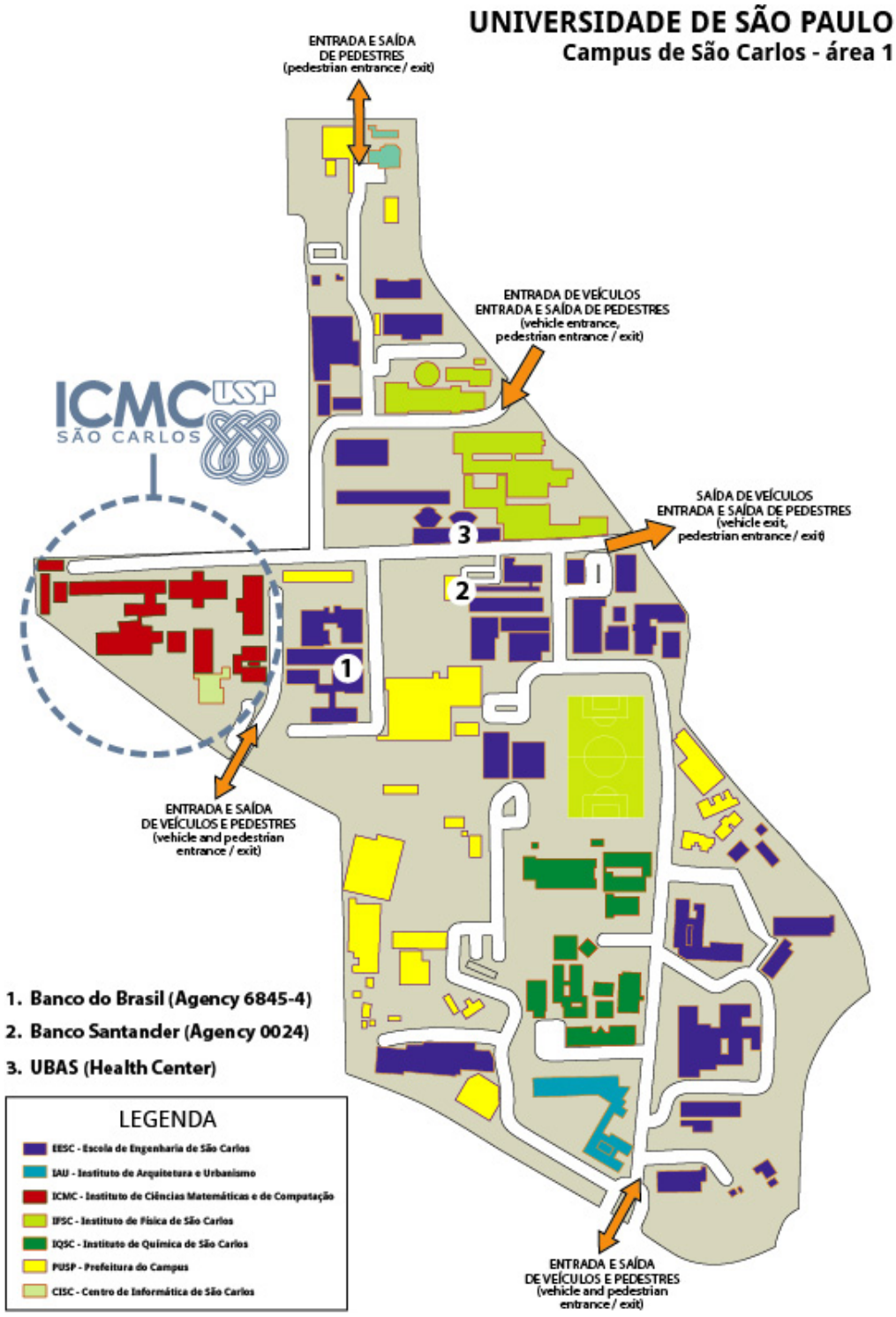

Figure 1: Campus map

Figure 2: ICMC map

Contents

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

2018 Chapter

General Information

Conference site

The meeting will take place at Buildings 5 and 6, and also in the Coffee Area. All these buildings are indicated in the map on page 7.

Plenary talks will take place at the Auditorium (Building 6)

Special session on Conservation Laws and Transport Equations & Fluid Dynamics in room 5-104 (Building 5)

Special session on Dispersive Equations in room 5-004 (Building 5)

Special session on Elliptic Equations in room 5-101 (Building 5)

Special session on Linear Equations in room 5-002 (Building 5)

Special session on Nonlinear Dynamical Systems & Computational Dynamics at the Auditorium (Building 6)

Special session on Ordinary and Functional Differential Equations in room 5-103 (Building 5)

Poster session in Coffee Room (ground floor of the Library)

Registration

The registrations will be made in the following schedule:

Sunday, February 4^{th}: From 18:00hs to 19:00hs in the lobby of Anacã Hotel.

Monday, February 5^{th}: From 8:00hs to 8:50hs in the entrance of the ICMC Auditorium (Building 6).

We will provide you a badge at registration. Please wear your badge at the event.

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

Registration Fees

Student Fee: R$ 50,00 (reais).

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

Regular and student registration fees include access to sessions and lectures, conference materials and refreshments at coffee breaks.

Financial support

The financial support from the local organizing committee will be available on Tuesday, February 6^{th}, at the Financial Office (4, map of page 7). In order to receive your support, it is mandatory to completely fill out the on-line registration form available at `summer.icmc.usp.br/user_summer/` .

Meals and refreshments

There are several restaurants near the campus. You can find them by looking at the city map located on page 5. There are also choices of pizzerias. At night, there are many bars around the city.

There is also a canteen on the campus (7, map at page 7) where you can have either snacks or lunch.

Social events

Monday, February 5^{th}*:* Happy Hour at 18:00hs at Água Doce Cachaçaria at 1625, Nove de Julho Street (R42, map at pages 5 and 6).

Tuesday, February 6^{th}*:* Photo of the meeting at 12:10hs at ICMC.

Tuesday, February 6^{th}*:* Conference Banquet at 20:00hs at Café Sete at 1447, Sete de Setembro Street (R34, map at pages 5 and 6).

Health emergencies

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

Money exchanges

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

• Confidence Câmbio at Shopping Center Iguatemi. The working hours are from 8:00 to 19:00 (Mon-Fri) and from 9:00 to 16:00 (Sat).

• Fitta Câmbio e Turismo at 1976, Episcopal Street. The working hours are from 9:30 to 17:30 (Mon-Fri).

Smoking

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

Computer and wireless LAN use

There will be available computers and a printer for use at the lobby of the Auditorium.

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

1. Enable wireless on your device.
2. Join the ICMC-GUEST wireless network.
3. Open a browser and try to visit any website.

4. You will be redirected to a login page. Enter the login and password as follows:

   User Name: *summer*

   Password: smode18@

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

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

2018 Chapter

Plenary Talks

Plenary Speaker

A delay differential equation with a solution whose shortened segments are dense

Hans-Otto Walther
University of Giessen

We construct a delay functional $d : Y \to (0, r)$ on an infinite-dimensional subset $Y \subset C^1_r = C^1([-r, 0], \mathbb{R})$, $r > 1$, so that the delay differential equation

$$x'(t) = -\alpha\, x(t - d(x_t)), \quad \alpha > \pi/2,$$

with $x_t : [-r, 0] \ni s \mapsto x(t + s) \in \mathbb{R}$ in C^1_r for $t \geq 0$, has a continuously differentiable solution $x : [-r, \infty) \to \mathbb{R}$ whose *restricted* segments $[-1, 0] \ni s \mapsto x(t + s) \in \mathbb{R}$, $t \geq 0$, are dense in C^1_1. This implies complicated behaviour of the trajectory $[0, \infty) \ni t \mapsto x_t \in C^1_r$.

Optimal Transport on Finite Graphs

Haomin Zhou
Georgia Institute of Technology

Optimal transport theory in continuous space has been extensively studied in the past few decades. In this talk, I will present similar matters on discrete spaces. Various recent developments related to free energy, Fokker-Planck equations, as well as Wasserstein distance on graphs will be discussed, some of them are rather surprising. This presentation is based on several joint papers with Shui-Nee Chow (Georgia Tech), Wen Huang (USTC), Wuchen Li (UCLA), Yao Li (U. Mass).

Bifurcations and complex dynamics of compartmental models with hospital resources

Huaiping Zhu, Chunhua Shan, Yingfei Yi
York University

We propose to study a compartmental model with a standard incidence rate and a nonlinear recovery rate to study the impact of public health resources on the control of infectious diseases. Cusp, focus and elliptic type of nilpotent singularities of codimension 3 are discovered and analyzed in this three dimensional model. In this talk, I will present the bifurcation analysis of the nilpotent singularities, existenice of multiple limit cycles and fast-slow dynamics of the model.

Solvability of Semilinear Equations in Hilbert Spaces and Applications

Hugo Leiva, Antonio Acosta
Yachay Tech University, Ecuador

In this paper we study the existence of solutions for a broad class of abstract semilinear equations in Hilbert spaces. This is done by applying Rothe's Fixed Point Theorem and a characterization of dense range linear operators in Hilbert spaces. As an applications we study the approximate controllability of a semilinear control system governed by a semilinear evolution equations, and a particular case of this is a control system governed by a semilinear heat equation with interior control.

The Agmon-Douglis-Nirenberg problem for dynamic boundary conditions

Jerome A. Goldstein, Gisele Ruiz Goldstein, Michel Pierre
University of Memphis

Of concern are certain reaction-diffusion systems with total mass bounded in the L^1 norm. The solution of this problems requires results from the study of a uniformly elliptic heat equation on a bounded domain, with Wentzell (or dynamic) boundary conditions incorporating the Laplace-Beltrami operator. We prove that the semigroup governing this linear problem is analytic in the right half plane in L^p for all $p \geq 1$ and for C in the sup norm. The proof is quite long and delicate. We will attempt to outline the proof, but there will not be enough time to do the nonlinear applications.

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

John Mallet-Paret
Brown University

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

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

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

The Qualitative Theory of Ordinary Differential Equations and Structural Stability in Brazil: Genesis and Perspectives.

Jorge Sotomayor
Universidade de São Paulo, IME

The following subjects will be addressed:

A. An outline of the transition from the work of Henri Poincaré (France, around 1881) to that of Mauricio Peixoto Brazil (around 1962), touching on the contributions of Alexander Andoronov, Lev Pontrjagin and Evgenia Leontovich (Russia, years 1935 - 1955) with a brief interlude in USA with Solomon Lefschetz (around 1950).

A_1. Poincaré: Connection of Celestial Mechanics and the Stability of the Solar System and the Qualitative Theory of Ordinary Differential Equations (QTDE) on the Plane and on Surfaces. The phase portrait.

A_2. Outline of a Mathematical Theory of Structural Stability and Bifurcations of ODEs in Andronov's Gorkii School.

A_3. Lefschetz books and the divulgation in the West of the work around A_2.

A_4. Contributions of Peixoto, assimilating and extending partially A_1 and A_2.

B. A historical landmark for the starting of advanced studies on the Qualitative Theory of Ordinary Differential Equations and Dynamical Systems in Brazil: Peixoto's Seminar at IMPA, Rio de Janeiro, $1962 - 4$.

B_1. A glimpse into the works accomplished at Peixoto's Seminar .

C. On the repercussion of Peixoto's work in Brazil and abroad.

C_1. 1981, Structural Stability and Bifurcations of bidimensionais EDOs. The work of Carlos Gutierrez.

C_2. 1991, Principal curvature configurations on surfaces in euclidean space.

C_3. 2009, Extension in one dimension and co-dimension on the domain and co-domain in C_2.

D. On the present and future of the research on the Qualitative Theory of Ordinary Differential Equations and Dynamical Systems in Brazil. Arthur Avila Fields Medal achievement.

[A.1] A. Chenciner, *Poincaré and the Three-Body Problem. In Progress in Mathematical Physics, vol 67. Birkhäuser, Basel.*

[A.2] J-M. Ginoux, *History of Nonlinear Oscillations Theory in France (1880-1940).* www.springer.com/la/book/9783319552385.

[B] J. Sotomayor, *Uma lista de problemas de EDO*; Rev. Mat. Estat, UNESP, 18, **2000.**

[C.1] J. Sotomayor, *Curvas definidas por Equações Diferencias no Plano,* Coloq. Bras. Mat, **1981**.

[C.2] J. Sotomayor, C. Gutierrez, *Lines of Curvature and Umbilic Points on Surfaces,* Coloq. Bras. Mat, **1991**.

[C.3] J. Sotomayor, R. Garcia, *Differential Equations of Classical Geometry, a Qualitative Theory,* Coloq. Bras. Mat, **2009**.

[C.4] S. Smale, *What is global analysis?*, Amer. Math. Monthly, v. 76,1, **1969.**

Estimates on the distance of Inertial Manifolds.

José M. Arrieta, Esperanza Santamaría
Universidad Complutense de Madrid

Motivated by the study of perturbation problems of reaction-diffusion equations and in particular trying to obtain good estimates on the distance of the attractors for the case of thin domains in $\mathbb{R}^d$, we are lead in a natural way to trying to obtain good estimates on the distance of invariant manifolds under very general hypotheses. In this talk we will consider a very general and abstract situation where the limit problem has an inertial manifold and will show that the perturbed problem also has an inertial manifold and, more important, we will obtain good estimates in the C^0 and $C^{1,\theta}$ norms of the inertial manifolds. The estimates are expressed in terms of the distance of the resolvent operators (which may have different phase spaces) and the distance of the nonlinearities in appropriate norms. This is a joint work with Esperanza Santamaría.

[1] J.M. Arrieta and E. Santamaría, Estimates on the distance of Inertial Manifolds, DCDS 34, 10 (2014), 3921-3944.
[2] J.M. Arrieta and E. Santamaría, $C^{1,\theta}$-Estimates on the distance of Inertial Manifolds (submitted) https://arxiv.org/abs/1704.03017.

TBA

Kening Lu
Brigham Young University

Stochastic 2D Navier-Stokes equations with infinite delay: existence, uniqueness and stability of solutions

Tomás Caraballo
Universidad de Sevilla

In this talk we report on recent results concerning a stochastic 2D Navier-Stokes system when the external force contains unbounded/infinite hereditary characteristics. The existence and uniqueness of solutions in the case of unbounded (infinite) delay are first proved by using the classical technique of Galerkin approximations. The local stability analysis of constant solutions (equilibria) is also carried out by exploiting several approaches. Namely, the Lyapunov function method, the Razumikhin-Lyapunov technique and by constructing appropriate Lyapunov functionals. Although, in general, it is not possible to establish conditions ensuring the exponential asymptotic behavior of the solutions, some sufficient conditions for the polynomial stability of the stationary solution in a particular case of unbounded variable delay will be provided. Many other interesting cases of unbounded delay terms remain as open problems. Also the global asymptotic behavior is an interesting topic which is being investigated.

Optimal transport on graphs with applications

Wuchen Li
University of California, Los Angeles

In recent years, optimal transport has witnessed a lot of applications in probability, statistics, physics, image processing, computer vision and machine learning. It provides a solid metric/measurement among histograms (densities) that incorporates the geometry of datas. In this talk, we consider optimal transport (Wasserstein metric) on finite graphs. Various recent developments related to dynamical systems, Shannon-Boltzmann entropy, Fisher information will be presented. Many applications in this direction will be discussed, including computation of the Wasserstein metric, image segmentations, population games and geometry of finite graphs.

Periodic Measures of Fokker-Planck equations

Yingfei Yi, Min Ji, Weiwei Qi, Zhongwei Shen
University of Alberta & Jilin University

We consider an Itô stochastic differential equation with weak drift and noise terms which depend on time periodically. The existence of periodic measures of the corresponding Fokker-Planck equation will be shown under suitable Lyapunov conditions. The approach is based on a periodic level-sets method and exterior estimates for linear parabolic PDEs.

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

2018 Chapter

Special Sessions

Conservation Laws and Transport Equations & Fluid Dynamics

Organizer: Gabriela Planas & Wladimir Neves

Abstract framework for the theory of statistical solutions

Anne Bronzi, Cecilia Mondaini, Ricardo Rosa
IMECC - UNICAMP

In this talk we will present an abstract framework for the theory of statistical solutions for general evolution equations. This theory extends the notion of statistical solutions initially developed for the 3D incompressible Navier-Stokes equations to other evolution equations that have global solutions which are not known to be unique. The main results are the existence of statistical solution for the initial value problem and the convergence of statistical solutions of regularized equations to statistical solutions of the original one. The wide applicability of the theory will be illustrated with the very 3D incompressible Navier-Stokes equations, a reaction-diffusion equation, a nonlinear wave equation and the 2D inviscid limit of statistical solutions of the Navier-Stokes to the Euler equations.

Global well-posedness for the rILW equation

César J. Niche
UFRJ

The regularized intermediate long-wave equation (rILW) models wave evolution at the interface of a stably stratified fluid consisting of two homogeneous layers, the upper one in a shallow water regime and the lower one in an intermediate depth regime. The rILW equation is asymptotically equivalent to the intermediate long-wave equation (ILW), but is is better suited for some applications and for direct numerical simulation.

In this talk, we address the global well-posedness of the rILW in Sobolov spaces H^s, with $s > 1/2$.

This is joint work with J. Schoeffel (UFPR), A. R. de Zárate (UFPR), H. Oquendo (UFPR) and D. Alfaro-Vigo (UFRJ).

Stochastic continuity equation with non-smooth velocity

David Alexander Chipana Mollinedo, Christian Olivera
UTFPR-Campus Ponta Grossa

In this work we study the one dimensional stochastic continuity equation:

$$\begin{cases} \partial_t u(t,x) + Div\big((b(x) + \dfrac{dB_t}{dt}) \cdot u(t,x)\big) = 0\,, \\ u|_{t=0} = u_0\,, \end{cases} \tag{1}$$

and we will show uniqueness of L^2-weak equation solutions for (1) with field vector (drift) only satisfying:

$$|b(x)| \leq k(1 + |x|)\,,$$

without assumptions on the divergence. For more details to see [1]. Joint work with Christian Olivera (Universidade Estadual de Campinas).

[1] D. A. C. Mollinedo and C. Olivera, *Stochastic continuity equation with non-smooth velocity*, Annali di Matematica Pura ed Applicata, (2017), 1-16.

Non-isothermal Navier-Stokes-Allen-Cahn equations

Gabriela Planas, Juliana Honda Lopes
Unicamp

This talk is concerned with a non-isothermal diffuse-interface model which describes the motion of a mixture of two viscous incompressible fluids. The model consists of modified Navier-Stokes equations coupled with a phase-field equation given by a convective Allen-Cahn equation, and energy transport equation for the temperature. This model admits a dissipative energy inequality. It is investigated the well-posedness of the problem in the two and three dimensional case without any restriction on the size of the initial data. Moreover, regular and singular potentials for the phase-field equation are considered.

Asymptotic behavior for the critical surface quasi-geostrophic equation on a strip in the limit of large dispersive forcing

Leonardo Kosloff, Gabriela Planas
Unicamp

We consider the 2D surface quasi-geostrophic equation with critical dissipation and dispersive forcing set on the vertical strip $[0,1] \times \mathbb{R}^2$, with Dirichlet boundary conditions for the surface temperature. Similar models for the quasi-geostrophic equation model of the potential vorticity have been treated where the presence of boundary layers serves to represent the western intensification of boundary currents.

Our aim is to display this phenomenon by constructing a boundary layer approximation which converges in the limit of large dispersive forcing. We first exhibit the boundary layer part for the stationary solution of the linear part of the equation following results for convection-diffusion models; this is known as the Stommel boundary layer. We then deal with the nonlinear terms using similar techniques as in the case of Ekman boundary layers for the analogous 3D Navier-Stokes-Coriolis system in the limit of fast rotation. The convergence of the approximation is shown in the energy norm.

Displacement convexity for the entropy in semidiscrete nonlinear Fokker-Planck equations

Matheus Santos, José A. Carrillo, Ansgar Jüngel
Universidade Federal do Rio Grande do Sul - UFRGS

The displacement λ-convexity of a nonstandard entropy with respect to a nonlocal transportation metric in finite state spaces is shown using a gradient flow approach. The constant λ is computed explicitly in terms of a priori estimates of the solution to a finite-difference approximation of a nonlinear Fokker-Planck equation. The key idea is to employ a new mean function, which defines the Onsager operator in the gradient flow formulation.

Initial-boundary value problem for stochastic transport equations

Wladimir Neves, Christian Olivera
Universidade Federal do Rio de Janeiro

This paper is concerned with the initial-boundary value problem for stochastic transport equations in bounded domains. For a given stochastic perturbation of the drift vector field, we prove existence and uniqueness of weak solutions with non-regular coefficients. The existence result relies strongly on the passage from the Stratonovich formulation into Itô's one, which is a completely new result for bounded domains. The strong stochastic trace theorem established in this paper is also essential to prove the existence. Moreover, the uniqueness of weak solutions is obtained under suitable conditions, which allow vacuum.

Dispersive Equations

Organizer: Marcia A. G. Scialom & Mahendra Panthee

Well-posedness and long-time behavior for the Schrödinger-Korteweg de Vries interactions on the half-line

Adán J. Corcho, Márcio Cavalcante
Universidade Federal do Rio de Janeiro

We consider the short-long wave interactions, modeled by the coupled equations:

$$\begin{cases} iu_t + u_{xx} = \alpha uv + \beta u|u|^2, & (x,t) \in \boldsymbol{R}^{\pm} \times (0,T), \\ v_t + v_{xxx} + \frac{1}{2}(v^2)_x = \gamma(|u|^2)_x, & (x,t) \in \boldsymbol{R}^{\pm} \times (0,T), \\ u(x,0) = u_0(x),\ v(x,0) = v_0(x), & x \in \boldsymbol{R}^{\pm}, \\ u(0,t) = f(t),\ v(0,t) = g(t), & t \in (0,T), \end{cases} \tag{2}$$

where $u = u(x,t)$ is a complex valued function, $v = v(x,t)$ is a real valued function and α, β, γ are real constants.

Under homogeneous boundary conditions for the right half - line we prove that local solutions in the energy space can be extended globally in time when $\alpha\gamma > 0$. On the other hand, for left half -line interactions with $\alpha\gamma < 0$ we show that, under special conditions of the initial data, certain weighted L^2-norms of the solutions blow-up at infinity with linear growth in time.

Fourth-order cubic nonlinear Schrödinger equation

Chulkwang Kwak
Pontificia Universidad Católica de Chile

We consider the fourth-order cubic nonlinear Schrödinger equation (4NLS) under the periodic boundary condition

$$i\partial_t u + \partial_x^4 u = |u|^2 u.$$

It is well-known that (4NLS) is globally well-posed in $L^2(\mathbb{T})$ and ill-posed (in the sense of non-existence) below $L^2(\mathbb{T})$. A proper model to study below $L^2(\mathbb{T})$ is the following *Wick ordered fourth-order cubic NLS* (4WNLS)

$$i\partial_t v + \partial_x^4 v = \left(|v|^2 - 2 \fint |v|^2 \, dx \right) v.$$

In this talk, we discuss the local well-posedness of (4WNLS) below L^2. Moreover, as an application of L^2 global well-posedness, we discuss the symplectic nonsqueezing property of (4NLS).

Minimizers and the orbital stability of periodic structures

Fábio Natali
Universidade Estadual De Maringá - UEM

In this talk, we establish a criterion for the orbital stability of periodic waves related to a general class of dispersive equations. We present sufficient conditions for the stability without knowing the positiveness of the associated hessian matrix. As applications of our method, we show the orbital stability of periodic waves that minimize a convenient Lyapunov functional.

Stability properties of solitary waves for fractional KdV-type models

Jaime Angulo Pava
USP

In this talk we shed new light on the stability properties of solitary wave solutions associated with models of Korteweg-de Vries type, when the dispersion is very lower. Via an approach of compactness, analyticity and asymptotic perturbation theory, we establish sufficient conditions for the existence of exponentially growing solutions to the linearized problem and so a criterium of spectral instability of solitary waves is obtained. Moreover, the nonlinear stability and spectral instability of the ground states solutions is obtained for some specific regimen of parameters. Via a Lyapunov strategy and a variational analysis we obtain the stability of the blow-up of solitary waves for the critical fractional KdV equation. The arguments presented in this investigation has prospects for the study of the instability of traveling waves solutions of other nonlinear evolution equations.

On the existence of solitary waves for an internal system of the Benjamin-Ono type

Jose R. Quintero, Gilberto Arenas
Universidad del Valle

In this talk, we discuss the existence of solitary wave solutions in the regime of large wave speed for a model of internal waves related with a regularized Benjamin-Ono system. The model considered describes the propagation of a weakly nonlinear internal wave propagating at the interface of two immiscible fluids with constant densities, which are contained at rest in a long channel with a horizontal rigid top and bottom, and the thickness of the lower layer is assumed to be effectively infinite (deep water limit), assuming that the density of the fluid below is greater than the density of the fluid above. The existence result is based on the theory of fixed points for a nonlinear positive operator defined on a cone in an appropriate Frechét space.

Well-posedness for coupled systems of KdV and mKdV type equations

Mahendra Panthee, Xavier Carvajal
UNICAMP

We consider initial value problems (IVPs) associated to two different systems consisting Korteweg-de Vries (KdV) and modified Korteweg-de Vries (mKdV) type equations and prove local well-posedness results for given data in certain low regularity Sobolev spaces.

Joint work with Xavier Carvajal from UFRJ.

On the model of fifth order KdV-BBM equation "finally"

Marcia Scialom, J. Bona, X. Carvajal, M. Panthee
Universidade Estadual De Campinas

Formally second-order mathematical descriptions of long-crested water waves propagating mainly in one direction are "finally" derived. These equations are analogous to the first-order approximations of KdV- or BBM-type. The advantage of these more complex equations is that their solutions involve a lot of modelling constants and for some of these constants the fifth order model is Hamiltonian. This

means that corresponding to physically relevant initial perturbations of the rest state, the solutions are expected to be accurate on a much longer time.

The initial-boundary value problem for the Kawahara equations on the half-line

Márcio Cavalcante de Melo, Chulkwang Kwak
Universidade Federal de Alagoas

In this talk we discuss about local well-posedness for the initial-boundary value problem associated to for the Kawahara equation on the half-line. The results are obtained in the low regularity setting by introducing an analytic family of boundary forcing operators, following the ideas developed by Colliander, Kenig, Holmer and myself. This is a joint work with Chulkwang Kwak.

Orbital stability of periodic traveling wave solutions for the Kawahara equation

Thiago de Andrade, Fabrício Cristófani, Fábio Natali
Universidade Tecnológica Federal do Paraná - UTFPR

In this work, we investigate the orbital stability of periodic traveling waves solution for the Kawahara equation

$$u_t + u^p u_x + u_{xxx} - u_{xxxxx} = 0, \tag{3}$$

where $u = u(x,t)$ is a real valued function with domain $\mathbb{R} \times \mathbb{R}$ and $p \geq 1$ is an integer. We prove that the periodic traveling wave, under certain conditions, minimizes a convenient functional by using an adaptation of the method developed by Grillakis, Shatah and Strauss [J. Funct. Anal. 74, 160-197 (1987)]. The required spectral properties to ensure the orbital stability are obtained by knowing the positiveness of the Fourier transform associated with the periodic wave as established by Angulo and Natali [SIAM J. Math. Anal. 40, 1123-1151 (2008)].

Elliptic Equations

Organizer: Claudianor O. Alves

Symmetry of positive solutions to semi-linear elliptic equations involving the Laplacian on $\mathbb{R}^N$

Andres I. Avila, Friedemann Brock
de La Frontera, CHILE

We show radial symmetry of positive solutions of $-\Delta u = f(|x|, u)$ on $\mathbb{R}^N$, satisfying $\lim_{|x|\to\infty} u(x) = 0$, where $f \sim |x|^{-l}u^q$ near $|x| = \infty$ and $u = 0$. A new ingredient is a comparison principle in half spaces. It allows to apply immediately the Moving Plane method once an asymptotic estimate of the form $\lim_{|x|\to\infty} |x|^\gamma u(x) =: \lambda > 0$ has been established.

Controlling the footprint of droplets

Antoine Laurain
University of São Paulo

The development of engineered substrates has progressed to an advanced level, which allows for control of the shape of sessile droplets on these substrates. Controlling local droplet shape via substrate surface tensions has various applications, such as directing the growth of bio-films and cell cultures, depositing a film of material onto a substrate in a particular pattern, or creating lenses with focal properties controlled by locally modifying substrate tensions.

We present an optimal control of a free boundary problem. Specifically, we show how to direct the shape of the droplet-substrate interface, also called "droplet footprint", by controlling the substrate surface tension. We use shape differential calculus to derive a gradient flow approach to compute equilibrium shapes for sessile droplets on substrates. We prove a shape sensitivity result with respect to the substrate surface tensions for the free boundary problem associated with the footprint. We then develop a gradient based optimization method to find the substrate surface tension yielding an equilibrium droplet shape with a desired footprint.

The influence of a metasolution on the behavior of the logistic equation with nonlocal diffusion coefficients

Cristian Morales Rodrigo, Tarcyana S. Figueiredo-Sousa, Antonio Suarez
Universidad de Sevilla

In this talk we use the bifurcation method and fixed point arguments to study a logistic equation with nonlocal diffusion coefficient. We prove the existence of an unbounded continuum of positive solutions that bifurcates from the trivial solution. The global behaviour of this continuum depends strongly on the value of the nonlocal diffusion coefficient at infinity as well as the relative position between the refuge of the species and the weight of the diffusion coefficient. Moreover, we show the complexity of the structure of the set of positive solutions using fixed point arguments.

Infinite Weak Solutions for the Henon-type equation in hyperbolic space

Flávio Almeida Lemos, Patrícia Leal, Bruno Mendes, Leandro Paes Leme
Universidade Federal de Ouro Preto

In this pacer, we study the existence of infinity results for Henon-type equation in hyperbolic space. The problem involves logarithm weight in the Poincaré model ball, with singularities on the boundary. Putting together this compactness embedding with Clark's theorem, a result of the multiply solutions is established.

Solvability for resonant elliptic systems

Francisco Odair de Paiva
Universidade Federal de São Carlos

We will present results of the existence of solutions for semilinear systems of elliptic equations. The nonlinear part has asymmetric behavior: resonant at the first eigenvalue in $-\infty$ and superlinear in $+\infty$. Our results are obtained via Theory of Degree.

Multiplicity of positive solutions for a quasilinear Schrödinger equation with an almost critical nonlinearity

Giovany Malcher Figueiredo
Universidade de Brasília

In this paper we prove an existence result of multiple positive solutions for the following quasilinear problem

$$\begin{cases} -\Delta u - \Delta(u^2)u = |u|^{p-2}u & \text{in } \Omega \\ u = 0 & \text{on } \partial\Omega, \end{cases}$$

where Ω is a smooth and bounded domain in $\mathbb{R}^N, N \geq 3$. More specifically we prove that, for p near the critical exponent $22^* = 4N/(N-2)$, the number of positive solutions is estimated below by topological invariants of the domain Ω: the Ljusternick-Schnirelmann category and the Poincaré polynomial.

Multiple solutions for a class of nonlocal and nonhomogeneous elliptic problems

Gustavo F. Madeira
UFSCar

We are concerned in this lecture with existence of multiple solutions for a class of nonlocal and nonhomogeneous elliptic problems. The nonlocal term is a Kirchhoff type term and the operator includes several examples like p-laplacian, p&q-laplacian, p-mean curvature, among others appearing in the applications. A particular important example of source term is a combination of convex and concave functions.

The results to be discussed establish the existence of infinitely many solutions of negative energy (which converge to zero uniformly) and infinitely many solutions of positive energy. The existence of at least two positive solutions to the problem will be also proved. In the final part of the lecture some extentions will be also discussed.

Generalized N-Laplacian equations involving critical exponential growth and concave terms in $\mathbb{R}^N$

Jefferson A. Santos, Uberlandio B. Severo
Universidade Federal de Campina Grande

In this work we establish the existence and multiplicity of nonzero and nonnegative solutions for a class of quasilinear elliptic equations, known as Generalized N-Laplacian, whose nonlinearity is allowed to enjoy the critical exponential growth with respect to a version of the Trudinger-Moser inequality and it can also contain convex terms in $\mathbb{R}^N$ $(N \geq 2)$. In order to obtain our results, we combine variational arguments in a suitable subspace of a Orlicz-Sobolev space with a version of the Trudinger-Moser inequality and Ekeland Variational Principle. In a particular case, we show the solution is a positive ground state.

Least energy nodal solutions for a defocussing Schrödinger equation with supercritical exponent

Jiazheng Zhou, Minbo Yang, Carlos Alberto dos Santos
Universidade de Brasília

In this paper we consider the existence of least energy nodal solution for the defocussing quasilinear Schrödinger equation

$$-\Delta u - u\Delta u^2 + V(x)u = a(x)[g(u) + \lambda|u|^{p-2}u] \text{ in } \mathbb{R}^N,$$

where $\lambda \geq 0$ is a real parameter, $V(x)$ is non-vanishing function, $a(x)$ can be a vanishing positive function at infinity, the nonlinearity $g(u)$ is of subcritical growth, the exponent $p \geq 22^*$, and $N \geq 3$. The proof is based on a dual argument on Nehari manifold by employing a deformation argument and a $L^\infty(\mathbb{R}^N)$-estimative.

A sub-supersolution method for a class of nonlocal problems involving the $p(x)$-Laplacian operator and applications

Leandro S. Tavares, Gelson G. G. dos Santos (UFPA), Giovany J. M. Figueiredo (UnB)
Universidade Federal do Cariri

In this work, we are interested in the existence of solutions for the nonlocal problem

$$\begin{cases} -\mathcal{A}(x, |u|_{L^{r(x)}})\Delta_{p(x)}u &= f(x,u)|u|^{\alpha(x)}_{L^{q(x)}} + g(x,u)|u|^{\gamma(x)}_{L^{s(x)}} \text{ in } \Omega, \\ u &= 0 \text{ on } \partial\Omega, \end{cases}$$

where Ω is a bounded domain in $\mathbb{R}^N$, $|.|_{L^{m(x)}}$ is the norm of the space $L^{m(x)}(\Omega)$, $-\Delta_{p(x)}u := -div(|\nabla u|^{p(x)-2}\nabla u)$ is the $p(x)-$Laplacian operator, $r, q, s, \alpha, \gamma : \Omega \to [0, \infty)$ are measurable functions and $\mathcal{A}, f, g : \overline{\Omega} \times \mathbb{R} \to \mathbb{R}$ are continuous functions satisfying certain conditions. Our approach is based on a new sub-supersolution method.

Existence of a positive solution to a nonlinear scalar field equation with zero mass at infinity

Liliane A. Maia, Mónica Clapp
UNB - Universidade de Brasília

We establish the existence of a positive solution to the problem

$$-\Delta u + V(x)u = f(u), \qquad u \in D^{1,2}(\mathbb{R}^N),$$

for $N \geq 3$, when the nonlinearity f is subcritical at infinity and supercritical near the origin, and the potential V vanishes at infinity. Our result includes situations in which the problem does not have a ground state. Then, under a suitable decay assumption on the potential, we show that the problem has a positive bound state.

This is joint work with Mónica Clapp (UNAM, México).

On a fourth-order elliptic equation

Marcelo F. Furtado, Giovany M. Figueiredo, João Pablo P. Silva
UnB

We present results of existence and multiplicity of solutions for the problem

$$\begin{cases} \Delta^2 u + \lambda \Delta u = |u|^{2^*-2}u, \text{ in } \Omega, \\ u, -\Delta u > 0, \text{ in } \Omega, \quad u = \Delta u = 0, \text{ on } \partial\Omega, \end{cases}$$

where $\Omega \subset \mathbb{R}^N$, $N \geq 5$, is a bounded regular domain, $\lambda > 0$ and $2^* = 2N/(N-4)$ is the critical Sobolev exponent for the embedding of $W^{2,2}(\Omega)$ into the Lebesgue spaces.

On the parameter identification problem in elliptic systems.

Nilson Costa Roberty
Federal University of Rio de Janeiro

The objective of this presentation is describes some important aspects related with the reconstruction of parameters in models described with elliptic partial differential equations. Incomplete information about coefficients and source is compensated by an overprescription of Cauchy data at the boundary. The methodology we propose explores concepts as: Lipschitz Boundary Dissection; Complementary Mixed Problems with trial parameters; Internal Discrepancy Fields. The main techniques are variational formulation, boundary integral equations and Calderon projector. A specialized Finite Elements formulation is developed and used in the investigation of this class of problems, i.Ã©., for the solution of Multiple Complementary Direct Mixed Problems with wrong values of trials parameters. We also present and discuss: A Theorem on Complementary Solutions; The existence of Discrepancy Fields for trials with wrong parameters values; The Reciprocity Gap equation for Discrepancy fields parameter determination; The Variational Method for Discrepancy Fields parameter determination; A annihilator set condition for Discrepancy fields parameter determination.

A nonhomogeneous Brezis-Nirenberg problem on the hyperbolic space H^n

Raquel Lehrer, Paulo Cesar Carrião , Olímpio Hiroshi Miyagaki, André Vicente
UNIOESTE

A nonhomogeneous Brezis-Nirenberg problem on the hyperbolic space H^n is considered. By the use of the stereographic projection the problem becomes a singular problem on the boundary of the open ball $B_1(0) \subset R^n$.Thanks to the Hardy inequality, in a version due to the Brezis-Marcus, this difficulty involving singularity can be overcame. The mountain pass theorem due to Ambrosetti-Rabinowitz combined with Brezis-Nirenberg arguments is used to obtain a nontrivial solution.

Linear Equations

Organizer: Paulo L. Dattori da Silva

Globally hypoellipticity for Strongly Invariant Operators

Alexandre Kirilov, Wagner Augusto Almeida de Moraes
Universidade Federal do Paraná

Let M be a closed smooth manifold endowed with a positive measure dx. Given an elliptic positive pseudo-differential operator E on M, we consider an orthonormal basis consisting of eigenfunctions of E and introduce a discrete Fourier analysis on M associate to the operator E. Next, by using the notion of strongly invariant operators and of the corresponding matrix-symbols, as defined by Delgado and Ruzhansky, we analyze the regularity of solutions of differential operators defined on a closed manifold.

In this talk we will show necessary conditions and a sufficient condition to a strongly $E-$invariant operator P defined on on $\mathcal{D}'(M)$ be globally hypoelliptic on M. Racalling that, we say that P is globally hypoelliptic if $u \in C^\infty(M)$ whenever we have $Pu \in C^\infty(M)$.

[1] Delgado, J., Ruzhansky, M.: Schatten classes on compact manifolds: kernel conditions, J. Funct. Anal., 267(3) (2014), 772-798. doi10.1016/j.jfa.2014.04.016.

[2] Greenfield, S.J., Wallach, N.R.: Remarks on global hypoellipticity. Trans. Am. Math. Soc., 83 (1973), 153-164. doi10.2307/2038523.

Gevrey Regularity for Solutions of a Certain Class of Systems

Alexandre Arias Junior, Alexandre Kirilov, Cleber de Medeira
Universidade Federal do Paraná

Consider the following system of differential operators acting in the space of periodic ultradistributions $D'_{s,2\pi}(\boldsymbol{R}^n_t \times \boldsymbol{R}_x)$

$$\mathbb{L} \doteq \begin{cases} L_1 &= \dfrac{\partial}{\partial t_1} - c_1(t_1)\dfrac{\partial}{\partial x} \\ L_2 &= \dfrac{\partial}{\partial t_2} - c_2(t_2)\dfrac{\partial}{\partial x} \\ &\vdots \\ L_n &= \dfrac{\partial}{\partial t_n} - c_n(t_n)\dfrac{\partial}{\partial x} \end{cases}$$

where $c_j = c_j(t_j)$ is a function in the space $G^s_{2\pi}(\boldsymbol{R}_{t_j})$ of Gevrey periodic fucntions of order $s \geq 1$, for all $j = 1, \ldots, n$.

We say that $\mathbb{L}$ is globally G^s-hypoelliptic if $u \in G^s_{2\pi}(\boldsymbol{R}^n_t \times \boldsymbol{R}_x)$ whenever $u \in D'_{s,2\pi}(\boldsymbol{R}^n_t \times \boldsymbol{R}_x)$ and $L_j u \in G^s_{s,2\pi}(\boldsymbol{R}^n_t \times \boldsymbol{R}_x)$, for all $j = 1, \ldots, n$.

In this talk we discuss necessary and sufficient conditions to the system $\mathbb{L}$ being globally G^s-hypoelliptic.

[1] Bergamasco, A.P.: Remarks about global analytic hypoellipticity, Trans. of the AMS, 351(10) (1999), 4113-4126.

[2] Petronilho, G.: Ultradistribuições Gevrey Periódicas em $\mathbb{R}^n$, Apostila do curso apresentado na I EBED - UNICAMP, (2003).

Riemann-Hilbert problem for a class of planar complex vector fields

Camilo Campana
UFSCar

Let L be a vector field defined in an open subset $\tilde{\Omega}$ of the plane satisfying the following property: For each point p, either L is elliptic at p or there exist local coordinates (x, y) centered at p such that L becomes (near p) a nonzero multiple of the vector field $\frac{\partial}{\partial y} - i|y|^{\sigma}\frac{\partial}{\partial x}$ for some $\sigma > 0$. In this study the focus is in the understanding of the boundary value problem

$$\begin{cases} Lu = au + b\overline{u} + f & \text{in} \quad \Omega, \\ \Re(\overline{\Lambda}u) = \varphi & \text{on} \quad \partial\Omega, \end{cases}$$

on a simply connected domain $\Omega \subset\subset \tilde{\Omega}$ with $a, b, f \in L^p(\Omega)$ and $\Lambda, \varphi \in C^{\alpha}(\partial\Omega)$, $|\Lambda| = 1$, $0 < \alpha < 1$. The use of properties of an associate integral operator together with the Fredholm alternative, allows us to establish solvability when the index is nonnegative.

Gevrey perturbations for a class of differential operators

Eduardo Henrique Fernandes Rosa, Alexandre Kirilov, Fernando de Avila Silva
Universidade Federal do Paraná

Let us consider the operator

$$L = \partial_t - c(t)\partial_x$$

on the space $D'_{s,2\pi}(\mathbb{R}^2)$ of periodic ultradistributions on the plane, where $c(t) = a(t)+ib(t) \in G^s_{2\pi}(\mathbb{R})$ and $s \geq 1$.

We say the operator L is globally G^s-hypoeliptic in $\mathbb{R}^2$ if the conditions $u \in D'_{s,2\pi}(\mathbb{R}^2)$ and $Lu \in G^s_{2\pi}(\mathbb{R}^2)$ imply $u \in G^s_{2\pi}(\mathbb{R}^2)$.

In this presentation we are interested in the effect of zero order perturbations in the preservation of the global G^s-hypoelipticity of L, more precisely: if L is globally G^s-hypoeliptic and λ is a function in $G^s_{2\pi}(\mathbb{R}^2)$, we show conditions to guarantee that the perturbed operator $L_\lambda = L - \lambda(t, x)$ is globally G^s-hypoeliptic.

We also consider the operator

$$L_\lambda = \partial_t - c(t)\partial_x + \lambda(t, x, y),$$

on $D'_{s,2\pi}(\mathbb{R}^{n+2})$, $n \geq 1$, here $\lambda \in G^s_{2\pi}(\mathbb{R}^{n+2})$, $t, x\, in\mathbb{R}$ and $y \in \mathbb{R}^n$. We show that, when the condition $(\mathcal{P})$ of Nirenberg-Treves is satisfied, the G^s-global hypoeliticity of the operator L_λ is equivalent to its injectivity in $G^s_{2\pi}(\mathbb{R}^{n+2})$.

[1] Bergamasco, A. P.: Remarks about global analytic hypoellipticity, Trans. of the AMS, 351(10) (1999), 4113-4126.

[2] Petronilho, G.: Ultradistribuições Gevrey Periódicas em $\mathbb{R}^n$, Apostila do curso apresentado na I EBED - UNICAMP, (2003).

[3] Takahashi, L. T.: Hipoeliticidade Global de Certas Classes de Operadores Diferenciais Parciais, Dissertação, UFSCar, São Carlos, (1995).

[4] Kirilov, A.: Algumas Observações sobre a Hipoeliticidade Global no Toro n-dimensional, Dissertação, UFSCar, São Carlos, (1996).

Local Solvability for a class of linear operators in Besov spaces

Evandro Raimundo da Silva
USP

We show local solvability in Besov spaces for a class of first order linear operators L defined on an open set of $\mathbb{R}^{n+1}$, $n \in \mathbb{N}$, satisfying the condition (P) of Nirenberg-Treves and whose coefficients are Hölder continuous. Moreover, when $n = 1$, we show local solvability for L in $L^\infty(\mathbb{R}, B^1_{s,s}(\mathbb{R}))$, $B^s_{1,1}(\mathbb{R}^2)$ and $L^q(\mathbb{R}; B^s_{p;q}(\mathbb{R}))$, $1 < p < \infty$, $1 \leq q \leq \infty$, $s \in \mathbb{R}$. Recalling that $C^s = B^s_{1,1}$, if $s > 0$ and not an integer (Hölder space), then we have local solvability for L in $L^1(R; C^s(\mathbb{R}))$ and $C^s(\mathbb{R}^2)$.

Dirichlet-to-Neumann semigroup with respect to a general second order eigenvalue problem

Jamil Abreu, Érika Capelato
Universidade Federal do Espírito Santo

In a recent paper, W. Arendt and A.F.M. ter Elst [3] have extended the classical form method in many ways. If $j : V \to H$ is a bounded linear operator with dense range and $\mathfrak{a} : V \times V \to \mathbb{K}$ is a continuous sesquilinear form which is j-elliptic in the sense that

$$\operatorname{Re} \mathfrak{a}(u,u) + \omega \|j(u)\|_H^2 \geqslant \alpha \|u\|_V^2 \quad (u \in V)$$

for some constants $\omega \in \mathbb{R}$ and $\alpha > 0$, then an operator A on H can be associated to $\mathfrak{a}$ in such a way that

$$\begin{aligned} &x \in \mathcal{D}(A) \text{ and } Ax = f \text{ if, and only if} \\ &\quad x = j(u) \text{ for some } u \in V \text{ and } \mathfrak{a}(u,v) = (f|j(v))_H \text{ for all } v \in V. \end{aligned} \tag{4}$$

By definition, the Dirichlet-to-Neumann operator is the operator D_0 acting on $L^2(\partial\Omega)$ with the property that $\varphi \in \mathcal{D}(D_0)$ and $D_0\varphi = h$ if, and only if there exists $u \in H^1(\Omega)$ with $\Delta u = 0$ on Ω, $u|_{\partial\Omega} = \varphi$ on $\partial\Omega$, and $\partial_\nu u = h$ in a weak sense. By showing that D_0 is associated with a j-elliptic form, namely, the classical Dirichlet form

$$\mathfrak{a}(u,v) = \int_\Omega \nabla u \cdot \overline{\nabla v}\, dx$$

with $j : H^1(\Omega) \to L^2(\partial\Omega)$ being the trace, Arendt & ter Elst have provided an interesting application of their theory where a non-injective j appears in a natural way. Consider the (formal) expression $\mathcal{A}u = -\operatorname{div}(a\nabla u) + b \cdot \nabla u - \operatorname{div}(cu) + du$.

Our research is motivated by some results in [2]. Here, we study the Dirichlet-to-Neumann operator, denoted by $D^{\mathcal{A}}_\lambda$, given by $\varphi \mapsto \partial_\nu u$ where $u \in H^1(\Omega)$ is a weak solution of $\mathcal{A}u = \lambda u$ on Ω subjected to the boundary condition $u|_{\partial\Omega} = \varphi$ and $\partial_\nu u$ is the 'weak conormal derivative'. Clearly, such an operator should be, at best, the associated operator, in the sense of (4), to the sesquilinear form $\mathfrak{a}_\lambda : H^1(\Omega) \times H^1(\Omega) \to \mathbb{K}$ defined by

$$\mathfrak{a}_\lambda(u,v) = \int_\Omega a\nabla u \cdot \overline{\nabla v}\, dx + \int_\Omega (b \cdot \nabla u)\overline{v}\, dx + \int_\Omega u(c \cdot \overline{\nabla v})\, dx + \int_\Omega du\overline{v}\, dx - \lambda \int_\Omega u\overline{v}\, dx. \tag{5}$$

Consider the number

$$\lambda_1^{\mathsf{D}}(\mathfrak{a}_0) := \inf_{u \in H^1_0(\Omega), u \neq 0} \frac{\operatorname{Re} \mathfrak{a}_0(u,u)}{\|u\|^2_{L^2(\Omega)}}. \tag{6}$$

Let $e^{-tD^{\mathcal{A}}_\lambda}$ be the semigroup on $L^2(\partial\Omega)$ generated by $-D^{\mathcal{A}}_\lambda$. In the following, A_{D} denotes the realization of $\mathcal{A}$ with Dirichlet boundary conditions. For simplicity, we also consider real scalars.

Theorem 0.0.1. *Let $\Omega \subset \mathbb{R}^N$ be a bounded connected open set with Lipschitz boundary. Suppose the matrix-valued function $a \in L^\infty(\Omega; \mathbb{R}^{N\times N})$ is symmetric and uniformily positive-definite in the sense that, for some $\kappa > 0$,*

$$a(x)\xi \cdot \xi \geqslant \kappa|\xi|^2 \quad (\xi \in \mathbb{R}^N, \text{a.e. } x \in \Omega). \tag{7}$$

Suppose the vector fields $b, c \in C^1(\overline{\Omega})^N$ are real and satisfy $\operatorname{div} b = \operatorname{div} c = 0$ and $b \cdot \nu = c \cdot \nu = 0$. Let $d \in L^\infty(\Omega)$ be real-valued. Suppose $\lambda \in \mathbb{R}\backslash\sigma(A_D)$.

1. *If $4\kappa^{-1}\|b-c\|^2_{L^\infty(\Omega)^N} + \|d^-\|_{L^\infty(\Omega)} + \lambda < \kappa\lambda_1^D$ then $e^{-tD^{\mathcal{A}}_\lambda}$ is positive.*
2. *If $4\kappa^{-1}\|b-c\|^2_{L^\infty(\Omega)^N} + \|d^-\|_{L^\infty(\Omega)} + \lambda < \kappa\lambda_1^D$ and $\lambda \leqslant d$ then $e^{-tD^{\mathcal{A}}_\lambda}$ is sub-Markovian.*
3. *If $\|d^-\|_{L^\infty(\Omega)} + \lambda < \kappa\lambda_1^D$ then $e^{-tD^{\mathcal{A}}_\lambda}$ is irreducible.*
4. *If $b = c$ and $\lambda_2 \leqslant \lambda_1 < \kappa\lambda_1^D - \|d^-\|_{L^\infty(\Omega)}$ then $0 \leqslant e^{-tD^{\mathcal{A}}_{\lambda_2}} \leqslant e^{-tD^{\mathcal{A}}_{\lambda_1}}$ in the sense of positive operators, i.e.*

$$0 \leqslant e^{-tD^{\mathcal{A}}_{\lambda_2}}\varphi \leqslant e^{-tD^{\mathcal{A}}_{\lambda_1}}\varphi \quad (t > 0,\ 0 \leqslant \varphi \in L^2(\partial\Omega)).$$

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On Uniqueness of Solutions for Evolution Equations

José Ruidival dos Santos Filho, Cezar Issao Kondo, Marcos Alves de Farias
Universidade Federal de São Carlos

In this talk we present a class of evolution partial differential equations for which the null function is the unique solution of the initial value problem. The class includes a equation of Kawahara type. An à priori decay of the solution is required. The technique is based in Carleman's estimates as proposed by L. Escauriaza e C. Kenig, among others. This work was concluded with the collaboration of Marcos A. de Farias and Cezar I. Kondo.

On local solvability for a class of generalized Mizohata equations

Luciele Rodrigues Nunes, José Ruidival dos Santos Filho
Universidade Federal do Rio Grande

Let L be a smooth complex valued vector field defined in an open subset Ω of $\mathbb{R}^2$ and $l \in \mathbb{N}$, $\ell \geq 1$. We say that L is an almost l-Mizohata operator in a submanifold Σ of Ω, if

(i) L and C_n are linearly dependent for $n = 0, 1, \ldots, l-1$ in Σ,

(ii) L and C_l are linearly independent in Σ,

where $C_0 = \overline{L}, C_1 = \left[L, \overline{L}\right], C_2 = [L, C_1], \ldots, C_n = [L, C_{n-1}]$.

Being $\ell > 1$ and odd, inspired by a result of N. Hanges for $\ell = 1$, we established necessary and sufficient conditions on a smooth function f for the local solvability of $Lu = f$ near Σ, where L is a ℓ-Mizohata operator.

Local Hardy-Sobolev inequalities for canceling elliptic differential operators

Tiago H. Picon (USP), Jorge Hounie (UFSCar)
Universidade de São Paulo

In this lecture we show that if $A(x, D)$ is a linear differential operator of order ν with smooth complex coefficients in $\Omega \subset \mathbb{R}^N$ from a complex vector space E to a complex vector space F, then the Hardy-Sobolev inequality

$$\int_{\mathbb{R}^N} \frac{|D^{\nu-\ell}u(x)|}{|x - x_0|^\ell}\, dx \leq C \int_{\mathbb{R}^N} |A(x, D)u| dx, \quad u \in C_c^\infty(B; E),$$

for $\ell \in \{1, ..., \min\{\nu, N-1\}\}$ holds locally at any point $x_0 \in \Omega$ if and only if $A(x, D)$ is elliptic and the constant coefficients homogeneous operator $A_\nu(x_0, D)$ is canceling in the sense of Van Schaftingen for every $x_0 \in \Omega$ which means that

$$\bigcap_{\xi \in \mathbb{R}^N \setminus \{0\}} a_\nu(x_0, \xi)[E] = \{0\}.$$

Here $A_\nu(x, D)$ is the homogeneous part of order ν of $A(x, D)$ and $a_\nu(x, \xi)$ is the principal symbol of $A(x, D)$.

This is joint work with Jorge Hounie (UFSCar).

Solvability near the characteristic set for a class of first-order linear partial differential operators

Wanderley A. Cerniauskas, Paulo L. Dattori da Silva
Universidade Estadual de Ponta Grossa

In this talk we discuss the solvability of first-order differential equations in the form $Lu = pu + f$, where $L = \partial/\partial t + (a(x) + ib(x))\partial/\partial x$ is a complex vector field on $\Omega_\epsilon = (-\epsilon, \epsilon) \times S^1$, $\epsilon > 0$, with a and b belonging to $C^\infty((-\epsilon, \epsilon); \mathbb{R})$.

We will assume that $a(x) + ib(x) = x^n a_0(x) + ix^m b_0(x)$, where $m, n \in \mathbb{N}$ with $2 \leq m \leq 2n - 1$, and we will show that the zero order term p has influence in the solvability in a full neighborhood of Σ. In the case where $m = 2n - 1$ we are also interested in studying the Vekua-type equation

$$Lu = pu + q\overline{u} + f.$$

Nonlinear Dynamical Systems & Computational Dynamics

Organizer: Juliana F.S. Pimentel & Marcio Gameiro

On a competing two-component system

Adem Guengoer
Free University of Berlin

In molecular biology two-component systems (TCS) are mechanisms that allow for example bacteria to respond to environmental changes. An environmental stimulus activates the membrane-bound histedine kinase (HK), which transmits this signal to an intercellular response regulator (RR). Once activated the RR can then flow into the mechanisms, which allow the organism to answer to the external change. But this process can be disturbed by a second regulator, which hinders the organism from reacting. Amin, Kothamachu et al. [1] considered such a competing two-component system.
TCS can be described by a system of ODE's of chemical reaction network via [2]. In my talk I will present some results from my master's thesis, based on [1] and also an expansion to a general case of a competing TCS.

[1] Munia Amin, Varun B. Kothamachu, Elisenda Feliu, Birgit E. Scharf, Steven L. Porter, Orkun S. Soyer - Phosphate Sink Containing Two-Component Signaling Systems as Tunable Threshold Devices. PLOS Computational Biology (2014).

[2] Martin Feinberg - Lectures on Chemical Reaction Networks, unpublished written versions of lectures given at the Mathematics Research Center, University of Wisconsin (1979).

Blow up type and existence results of solutions for a nonlocal hyperbolic equation

Andre Vicente, Paulo Cesar Carriao, Raquel Lehrer
Universidade Estadual do Oeste do Paraná

In this paper we study the behaviour of solutions for the following nonlocal hyperbolic equation: $u_{tt} + (-\Delta)^s u + \lambda_0 u = f(u)$ in $\mathbb{R}^n \times (0,T)$, where, $\lambda_0 \geq 0$, $n \geq 3$ and $(-\Delta)^s$ is the fractional laplacian operator. We use the Pohozaev manifold combined with a new technique to explicit two invariant regions in the space of initial data. On the first one the solution blow up (in finite or infinite time) and in the second one the solution exists globally. Additionally, we prove the ground state solution of the elliptic problem associated to the original problem is unstable.

The Hartman-Grobman theorem with parameters and smooth linearization

Hildebrando M. Rodrigues
Universidade de São Paulo

This talk will be mostly based in the following papers:

1. H. M. Rodrigues & J. Solà-Morales, "On the Hartman-Grobman theorem with parameters", J. Dynam. Differential Equations 22 (2010) 473-489.

2. Hildebrando M. Rodrigues & J. Solà-Morales, "Differentiability with respect to parameters in global smooth linearization", J. Differential Equations 262 (2017) 3583-3596.

- Some historic results. Some Elementary Motivations. On the relationship between norms of bounded linear operators and their spectral radius. A Hartman-Grobman Theorem with parameters. Continuity of the Conjugation with respect to parameters. The Continuity of the Fixed Point with respect to parameters. The Differentiability of the Fixed Point with respect to parameters. A Hartman-Grobman Theorem with parameters. Differentiability of the Conjugation with respect to parameters.

Pullback attractors to analyze the effect of random and stochastic disturbances in the chemostat model

Javier Lopez-de-la-Cruz
University of Sevilla

Chemostat refers to a laboratory device used for growing microorganisms in a cultured environment and has been regarded as an idealization of nature to study microbial ecosystems at steady state, which is a really important and interesting problem due to the many applications that can be found in the real life. The simplest chemostat device consists of three interconnected tanks called *feed bottle*, *culture vessel* and *collection vessel*. The nutrient is pumped from the first tank to the culture vessel, where the interactions between the species and the nutrient take place, and there is also another flow being pumped from the culture vessel to the third tank such that the volume of the culture vessel remains constant. Nevertheless, some drawbacks are found when considering deterministic chemostats since they are not a good approach to the real ones. Because of this reason, we are really interested in random and stochastic chemostat models, which have been proved to be very close to the ones in the laboratory.

In this talk, some random and stochastic disturbances in the chemostat model will be analyzed by making use of the modern techniques concerning the theory of random dynamical systems. Particularly, the existence and uniqueness of global solution will be stated and the existence and uniqueness of pullback random attractor will be also proved. Thanks to a deeper analysis involving the internal structure of the pullback random attractor, we will be able to provide conditions to ensure the persistence of the microbial biomass, which is also the main goal pursued by biologists. Finally, we will show several simulations which will support the results proved throughout the talk and will help us to decide which kind of noise is more appropriated to model the real chemostats.

Spiral Waves in Circular and Spherical Geometries: The Ginzburg-Landau Paradigm

Jia-Yuan Dai
Free University of Berlin

In this talk we prove the existence of m-armed spiral wave solutions for the complex Ginzburg-Landau equation in the circular and spherical geometries. Instead of applying the shooting method in the literature, we establish a functional approach and generalize the known results of existence for rigidly-rotating spiral waves. Moreover, we prove the existence of two new patterns: frozen spirals in the circular and spherical geometries, and 2-tip spirals in the spherical geometry.

Properties of Differentiable m-Convex Functions

José Luis Sánchez, Teodoro Lara, Edgar Rosales
Universidad Central de Venezuela

In this research we establish some inequalities involving both m-convex and strongly m-convex differentiable, or twice differentiable, functions defined on an open m-convex subset of a general normed linear space.

Unbounded Attractors Under Perturbations

Juliana F. S. Pimentel
UFABC

We put forward the recently introduced notion of unbounded attractors. These objects will be addressed in the context of a class of 1-D semilinear parabolic equations. The nonlinearities are assumed to be non-dissipative and, in addition, defined in such a way that the equation possesses unbounded solutions as time goes to infinity. Small autonomous and non-autonomous perturbations of these equations will be treated.

On global attractors for dynamical systems without natural metrics

Junya Nishiguchi
Tohoku University

A global attractor is a notion for a topological semi-dynamical system whose phase space is a metric space. It should be noticed that the notion of a global attractor depends on the specific choice of a metric. In this talk, we "define" global attractors in the context of the "non-existence of natural metrics" of the phase space and study those properties. This includes a case where the phase space is a Fréchet space, which is motivated by differential equations with unbounded delay. We obtain sufficient conditions for the existence, which will be applied to such equations.

Stationary solutions and stability in a non-autonomous equation with delay

Luis Felipe Rivero, Tomás Caraballo, Antonio Miguel Márquez-Durán
Universidade Federal Fluminense

Our aim in this work is the study of the existence and uniqueness of solutions for a non-classical and non-autonomous diffusion equation containing infinite delay terms. We also analyze the asymptotic behaviour of the system in the pullback sense and, under suitable additional conditions, we obtain global exponential decay of the solutions of the evolutionary problem to stationary solutions.

Stability of wave equations on non-increasing moving boundary domains

Ma To Fu
ICMC - USP

There are many studies on wave equations defined on moving boundary domains. However, it is known that shrinking a domain produces a gain of energy. Therefore all known results on stability of wave equations with moving boundary assume that the domain is expanding. Our objective is to show that non monotone domains can be considered by adding a suitable boundary dissipation.

Nonlocal problems in perforated domains

Marcone Pereira, Julio Rossi
Universidade de São Paulo

In this talk we analyze the asymptotic behavior of a nonlocal equation widely used to model diffusion process [1]. We consider the problem

$$f(x) = \int_B J(x-y)(u(y)-u(x))dy$$

with x taking place in a perforated domain $\Omega^\epsilon \subset \Omega$. Here the kernel J is a non-singular function. We think about Ω^ϵ as a fixed set Ω from where we have removed a subset A^ϵ that we call the holes. We deal both with the Neumann and Dirichlet conditions in the holes and assume a Dirichlet condition outside Ω. In the later case we impose that u vanishes in the holes but integrate in the whole $\mathbb{R}^N$ ($B = \mathbb{R}^N$) and in the former we just consider integrals in $\mathbb{R}^N$ minus the holes ($B = \mathbb{R}^N \setminus A^\epsilon$)). Assuming weak convergence of the holes, specifically, under the assumption that the characteristic function of Ω^ϵ has a weak limit, $\chi_\epsilon \rightharpoonup \mathcal{X}$ weakly* in $L^\infty(\Omega)$, we analyze the limit as $\epsilon \to 0$ of the solutions to the nonlocal problems proving that there is a nonlocal limit equation [2]. In the case in which the holes are periodically removed balls, we obtain that the critical radius is of order of the size of the typical cell (that gives the period). In addition, in this periodic case, we also study the behavior of these nonlocal problems when we rescale the kernel in order to approximate local partial differential equations.

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[2] M. C. Pereira and J. D. Rossi. *Nonlocal problems in perforated domains*. Submitted.

Signed response to reaction function perturbations in chemical reaction networks

Nicola Vassena
Free University Berlin

We consider general systems of differential equations derived from chemical reaction networks,

$$\dot{x} = S\mathbf{r}(x).$$

Here, x is interpreted as the vector of the concentrations of chemicals, S is the stoichiometric matrix and $\mathbf{r}(x)$ is the vector of reaction functions, which we consider as generic **positive given parameters**. From an abstract network point of view: the vector x represents the vertices, the matrix S is the incidence matrix and the vector $\mathbf{r}(x)$ refers to the directed arrows.
Sensitivity studies the network response to the perturbation of a single reaction function r_j, at equilibrium.
In previous work, Fiedler, Matano, the author et al., were able to present systematic criteria, which distinguish zero response from nonzero response, for any other reaction function (see [1, 2, 3, 4]). Their results were based on the network structure, only, and neither depend on numerical models of the reaction functions, nor on numerical values of their parameters. Our present work extends these results to provide for the first time criteria for predicting the sign of any nonzero response, without requiring any additional input information. That is, we investigate and answer the following question:

Is the nonzero response positive, negative or its sign is undetermined?

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A Lyapunov function for fully nonlinear parabolic equations

Phillipo Lappicy, Bernold Fiedler
Universidade de São Paulo

Lyapunov functions are used in order to prove stability of equilibria, or indicate a gradient-like structure of a system. Zelenyak (1968) and Matano (1988) constructed a Lyapunov functional for quasilinear parabolic equations. We modify his method to construct a Lyapunov functional for fully nonlinear parabolic equations.

Non-local diffusion systems applied to Disease models

Sergio Oliva
USP

Vector-borne diseases attract increasing attention in research because of their wide spread and potential to invade new world areas. We present some ways to introduce space models to the well known SIRSI and SISSI models. We point out some knew results when dealing with non-local diffusion in particular a reduction argument, through singular perturbation, to reduce the dimension of the system, since the human-host epidemics often acts on a much slower time scales than the one of the mosquitoes transmitting as a vector.

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[2] Dirk Brockmann, Lars Hufnagel and Theo Geisel. The scaling laws of human travel. Nature, 439(7075):462-465, 2006.

[3] Dirk Brockmann, Vincent David and Alejandro Morales Gallardo. Human mobility and spatial disease dynamics. Reviews of nonlinear dynamics and complexity, 2: 1-24, 2009.

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[6] Laura Forero Vega. Análise da dinâmica de uma rede para a dengue. Dissertação de Mestrado, IME-USP, 2017.

Ordinary-Functional Differential Equations

Organizer: Jaqueline Godoy Mesquita

Phase spaces on MFDEs with infinite delay

Claudio A. Gallegos, Hernán R. Henríquez, Jaqueline G. Mesquita
Universidad de Santiago de Chile

Motivated by the classical definition of phase space for retarded functional differential equations with infinite delay (see [1, 2]), and the axiomatic approach utilized in [1, 3], we discuss the employment of a different axiomatic definition of phase space for measure functional differential equations with infinite delay in the context of varying delay.

Acknowledgement This research was supported by CONICYT under grant DOCTORADO NACIONAL 2014-21140066 and DICYT-USACH.

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Zhukovskij Stability on Generalized Ordinary Differential Equations

Everaldo de Mello Bonotto, Marcia Federson, Marta Cilene Gadotti
ICMC - USP

In this talk, we present the theory of Zhukovskij stability for linear generalized ordinary differential equations. Using the obtained results of Zhukovskij stability and theorems of correspondence, we obtain new results of Zhukovskij stability for a class of measure differential equations.

Controllability and Observability in Generalized ODEs and Applications

Fernanda Andrade da Silva, Márcia Federson
Universidade de São Paulo

The aim of this paper is to establish results on controllability and observability for a system of linear generalized ODEs defined in a Banach space with initial data, controls and observations also belonging to a Banach space. Necessary and sufficient conditions are obtained. We apply our results to dynamic equations on time scales.

Properties of solutions of Neutral Differential Equations

Fernando Gomes de Andrade, Márcia Federson, Miguel Frasson, Patrícia H. Tacuri Córdova
ICMC - USP

In the field of differential equations there are many techniques and results to get properties of an equation and its solutions. But some of them are much sophisticated and maybe impractical for some kind of equations as, for instance, equations with infinite delay which demand certain restrictions. Having this in mind, we construct a scenario where it is possible to extract properties of a Neutral Differential Equation in a simpler way.

[1] A. Slavík. *Measure functional differential equations with infinite delay.* Nonlinear Analysis: Theory, Methods & Applications, 79, (2013): 140-155.

[2] P. H. Tacuri. *Equações diferenciais funcionais neutras, comportamento assintótico e representação*. Tese de Doutorado. Universidade de São Paulo.

Topological conjugacy on impulsive dynamical systems

Ginnara Mexia Souto, Everaldo de Mello Bonotto, Daniela Paula Demuner
UFES

In this work, we establish sufficient conditions to obtain topological conjugacy between two omega limits sets. We use character of recurrence to get the main results. We also to conclude some interesting properties of asymptotical recurrence motions (periodicity, almost periodicity) are preserved for points comparable by the recurrence character.

Stable embedded-methods for the variable step-size integration of stiff stochastic differential equations

Hugo de la Cruz
FGV - Escola de Matemática Aplicada

We introduce a class of explicit embedded methods for the variable step-size integration of stiff systems of additive noise stochastic differential equations. The construction of the schemes is carried out by combining the linearization approach with a suitably adapted Pad'e method resulting in stable embedded integrators. By using these integrators in the adaptive algorithm excessive restriction on the value of the step sizes -due to stability considerations- is avoided, which implies a significant reduction of the number of time-steps used and thus of the overall computation cost. Dynamical properties of the adaptive integrator are discussed and computer experiments are presented to illustrate the practical performance of the proposed method.

(Joint work with J. C. Jimenez (ICIMAF), P. de Maio (FGV))

Massera's Theorem on quantum calculus

Jaqueline G. Mesquita, Martin Bohner
Universidade de Brasília

In this work, we present versions of Massera's theorem for linear and nonlinear q-difference equations and present some examples to illustrate our result.

Perturbation theory of the Chemical Principle

Jayme De Luca
UFSCAR

I shall discuss the search for a common solution of two differential-delay equations for the electromagnetic two-body problem. The first condition is the equation of motion and the second is imposed to vanish the far-fields and is a condition in quasi-semiflow form.

Bifurcation of Solutions for Generalized ODE's and applications

Maria Carolina Stefani Mesquita Macena, Márcia Cristina Anderson Braz Federson, Karina Schiabel
Universidade Federal de São Carlos

We establish conditions on the existence of bifurcation points of solutions of generalized ordinary differential equations via coincidence degree theory. We also present applications to impulsive differential equations.

Theory of oscillations for functional differential equations with impulses

Marielle Aparecida Silva, Márcia Federson
Universidade de São Paulo

In this work, we present new criteria for the existence of oscillatory and nonoscillatory solutions of functional differential equations with impulses. We deal with the integral forms of the differential equations using the Perron and Perron-Stieltjes integrals. Thus the functions involved can have many discontinuities and they can be unbounded variation.

Dynamical Analysis of a Chemotherapy Model for Cancer Treatment

Xiaoying Han
Auburn University

Several mathematical models of chemotherapy for cancer treatment will be introduced. In particular, by using dynamical analysis, we will shown the effects of variable input, and the effects of delay in theotherapy treatments. It turns out that with the same amount of chemotherapy agent, variable input can be more effective than constant input, and delay can introduce a change in stability.

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

2018 Chapter

Poster Section

Poster

Organizer: Raquel Lehrer

Null Controllability of Some Nonlinear Degenerate 1D Parabolic Equations

Adeval Lino Ferreira, M. M. Cavalcanti, E. Fernández-Cara
Universidade Estadual de Londrina

The main goal of the present work is twofold: (i) To establish the well-posedness for certain type of nonlinear degenerate parabolic equations; (ii) To investigate the null controllability as well as decay rates estimates for those equations mentioned in (i). In order to achieve the controllability of the non-linear problem, we firstly study the controllability of the regularized linear problem like "Burgers-α". The state is the solution for the regularized equation, where the non-linear term $b(x)uu_x$ comes from the regularized $b(x)zu_x$ one and $z = (Id - \alpha^2 A)^{-1}$, where $A = \left(a\frac{\partial(.)}{\partial x}\right)_x$ and $\alpha > 0$ is a parameter arbitrarily small. We also investigate the results concerned with the behavior of null controls and their associated state when $\alpha \to 0$.

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Existence of Multi-peak Solutions for a Class of Quasilinear Problems in Orlicz-Sobolev Spaces

Ailton Rodrigues da Silva, Claudianor O. Alves
Universidade Federal do Rio Grande do Norte

The aim of this work is to establish the existence of multi-peak solutions for the following class of quasilinear problems

$$-\mathrm{div}\big(\epsilon^2\phi(\epsilon|\nabla u|)\nabla u\big) + V(x)\phi(|u|)u = f(u) \quad \text{in} \quad \mathbb{R}^N,$$

where ϵ is a positive parameter, $N \geq 2$, V, f are continuous functions satisfying some technical conditions and ϕ is a C^1-function.

"Drift-Diffusion" model

Eduardo Lima de Oliveira, Hector Vargas, Jiang Zhu, Abimael Fernando Loula
Instituto Federal de São Paulo

In this work, we investigated the numerical aspects in the treatment of a nonlinear system of partial differential equations, in which the nonlinearities are related to the couplings of the coefficients that depend on the temperature variation. In general, this model is obtained through the principle of electric charge conservation, known as Gaussian law, and the thermal energy variation, established by the heat equation. These equations are coupled to a subsystem that describes the charges transport inside a semiconductor material. The system formed by these four differential equations constitutes the "drift-diffusion" model with thermal effect. This is the object of our analysis.

Regularity theory for a semilinear free boundary problem under Dini-continuity conditions

Giane Casari Rampasso, Anne Caroline Bronzi, Edgard Almeida Pimentel
UNICAMP

In this poster we consider a semilinear equation of the form

$$Lu(x) = f(x,u) \quad \text{in} \quad B_1, \tag{8}$$

both in the variational and the nonvariational senses. We produce estimates in $\mathcal{C}^{1,1^-}_{loc}(B_1)$ for the solutions to (8) under fairly general assumptions on the data of the problem. For example, those include a Dini-continuity condition on the source term, together with the existence of a Newtonian potential of class $\mathcal{C}^{1,1}$. We argue through approximation techniques and methods in the so-called geometric tangential analysis. In fact, we relate our problems of interest to an auxiliary one, driven by the Laplacian operator. In this case, a richer regularity theory is available and we import information along a suitable geometric structure. This is joint-work with A. Bronzi (Unicamp) and E. Pimentel (PUC-Rio).

Homogenization of the p-laplacian in thin domains: The unfolding approach

Jean Carlos Nakasato, Marcone Corrêa Pereira
Universidade de São Paulo

In this work we apply the unfolding operator method to thin domains of type $R^\varepsilon = \left\{(x,y) \in \mathbb{R}^2 : 0 < x < 1, 0 < y < \varepsilon g(x/\varepsilon^\alpha)\right\}$, where $\alpha > 0$ and $g : \mathbb{R} \to \mathbb{R}$ is a L-periodic function not necessarily smooth satisfying $0 \leq g_0 \leq g(\cdot) \leq g_1$ for some fixed non-negative constants g_0 and g_1. This approach was presented by Arrieta and Pesqueira to study the linear Neumann problem $-\Delta u + u = f$ posed in two-dimensional thin domains with an oscillatory boundary. We generalize this problem to the nonlinear p-laplacian problem $-\Delta_p u + |u|^{p-2}u = f$ with homogeneous Neumann boundary condition, $p > 1$. As Arrieta and Pesqueira, we assume very mild hypothesis on the regularity of the oscillatory boundary to obtain the homogenized limit problem for the three different cases depending on the order of the period of the oscillations.

Asymptotic behavior of a parabolic problem with concentrated terms

Lucas Galhego Mendonça, Gleiciane da Silva Aragão
Universidade de São Paulo

In this study we analyze the asymptotic behavior of a nonlinear parabolic problem with homogeneous Neumann boundary conditions and with terms concentrating in a neighborhood of the boundary and this neighborhood shrinks to boundary when a parameter goes to zero.

Under certain conditions of critical growth of the nonlinearities, sign and dissipative, we show:

1. Existence and uniqueness of solutions.
2. The solutions of concentrated problem converge in a Sobolev space to the solution of parabolic problem with nonlinear Neumann boundary conditions.
3. Existence of global attractors.
4. The family of attractors is upper semicontinuous.

Weak regularity theory and nondifferentiable elliptic operators

Makson S. Santos, Edgard A. Pimentel
PUC-Rio

We consider fully nonlinear elliptic operators and produce two classes of results. First, we show that $C^{1,Log-Lip}(B_{1/2})$-estimates are available for a dense subset of the class of continuous viscosity solutions to

$$F(D^2u, x) = f \quad \text{in} \quad B_1,$$

where $f \in L^\infty(B_1)$. It accounts for our *weak regularity* result. Moreover, we consider

$$\min(H(D^2u), G(D^2u)) = g \quad \text{in} \quad B_1,$$

where g is in some appropriate Lebesgue space. Under asymptotic assumptions on the (λ, Λ)-elliptic operators H and G, we prove estimates for the solutions in Sobolev and Hölder spaces. Our techniques are based on geometric and approximation methods. This is joint work with E. Pimentel (PUC-Rio).

On a Vlasov-Fokker-Planck system

P. N. Seminario Huertas
Universidade de São Paulo

This work is devoted to the existence of weak solutions of the kinetic Vlasov-Fokker-Planck system in bounded domains with the self-consistent force field bounded at any time. The existence and uniqueness of weak solutions is proved as in Carrillo [1]. This fact is analyzed using a variational technique and the theory of elliptic-parabolic equations of second order.

[1] Carrillo, J.A., *Global Weak Solutions for the Initial-Boundary-Value Problems to the Vlasov-Poisson-Fokker-Planck System*, Math. Meth. in the Appl. Sci. **21**, 907-938 (1998).

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Existence of solution for a vibration problem of homogeneous string

Rodiak Nicolai Figueroa López, German Lozada Cruz
UNESP-IBILCE

In this work we study the existence and uniqueness of the weak solution of a mathematical model that describes the vibration of a string. This model is given by a wave equation with dynamic boundary conditions. For this we use the theory of C_0-semigroup. Also, we show that this model is conservative but is not exponentially stable following the ideas of [5].

Joint work with German Jesus Lozada Cruz (IBILCE/UNESP/BRAZIL).

[1] Brezis, H., *Operateurs maximaux monotones et semi-groupes de contractions dans les espaces de Hilbert*. Amsterdam: North Holland, 1973.

[2] Figueroa-López, R.N.; Lozada-Cruz, G. On a vibration problem of homogeneous string. In progress.

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Multiplicity of $W_0^{1,p(x)}(\Omega)$-solutions for local-singular-convex problem

Thiago Williams Siqueira Ramos, Carlos Alberto Pereira dos Santos
UnB

In this work we consider the multiplicity of solutions in $W_0^{1,p(x)}(\Omega)$ to an elliptic problem $-\Delta_{p(x)}u = a(x)u^{-\alpha(x)}+\lambda f(x,u)$, where $f(x,t)$ is locally $(p_+-1)-$superlinear, $\alpha(x) > 1-p_-$ can oscillate from positive to negative in multiple subregions of the interior and boundary of the domain and satisfies a general boundary condition. The proof is based on a combination of sub-super solution method and Mountain Pass Theorem in an appropriated functional.

[1] Perera K., Silva E.A.B., Existence and multiplicity of positive solutions for singular quasilinear problems. J. Math. Anal. Appl. 323 (2006), 1238 - 1252.

[2] Figueiredo, D.G., Gossez, J.P., Ubilla, P.: Local "superlinearity" and "sublinearity" for the p-Laplacian. J. Funct. Anal. 257, 721-752 (2009).

[3] Ramos T., Quasilinear Elliptic Singular Problems with variable exponents that may change sign involving the p(x)-Laplace operator, PhD. Thesis, MAT-UnB, 2017.

On the Navier-Stokes equations and asymptotic behavior in the rotational context in homogeneous Besov spaces.

Vladimir Angulo Castillo, Lucas Catão de Freitas Ferreira
Unicamp

We will present some results of asymptotic behavior type to the Navier-Stokes equations with Coriolis force. Initially we will show a result on the global well-posedness to these equations by taking initial data belonging to homogeneous Besov spaces. Next, we analyze in different spaces that involve the homogenous Besov spaces, the difference of solutions for different initial data when the rotation speed goes to infinity. To do this, we consider the mild formulation to the Navier-Stokes equations and obtain some space-time estimates of the Strichartz type for the Stokes-Coriolis semigroup.

Triviality of the centralizer of generic Hamiltonian flows

Wescley Bonomo, Paulo Varandas
Universidade Federal do Espírito Santo

This poster is part of my PhD Thesis. We establish a criterium for the triviality of the centralizer for flows, a problem related with the existence of symmetries for dynamical systems and prove that transitive flows displaying a dense set of periodic orbits and so that the periodic orbits of the same period are isolated have trivial centralizer. In particular we prove the triviality of the centralizer at isolated homoclinic classes of $\mathcal{C}^r$-flows $(r \geq 1)$. As applications of this criterium we show that the set of $\mathcal{C}^1$-flows that have trivial centralizer include: (i) $\mathcal{C}^1$-generic volume preserving flows, (ii) $\mathcal{C}^2$-generic Hamiltonian flows on a generic and full Lebesgue measure set of energy levels, and (iii) $\mathcal{C}^1$-open set of non-hyperbolic vector fields (that admit a Lorenz attractor).

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

2018 Chapter

Programme

Sunday 4 from 18:00 to 19:00, Registration at Anacã Hotel

Auditorium	MONDAY 5	TUESDAY 6	WEDNESDAY 7
08:00 – 08:50	**Registration**		
08:50 – 09:00	**Opening**		

Auditorium	Plenary Talks		
Chairman	*Hildebrando M. Rodrigues*	*John Mallet-Paret*	*Kening Lu*
09:00 - 09:40	Kening Lu	Hans-Otto Walther	Jerome A. Goldstein
09:40 - 10:20	John Mallet-Paret	Yingfei Yi	Huaiping Zhu
10:20 - 10:50	Coffee Break	Coffee Break & Poster Session	Coffee Break
Chairman	*Huaiping Zhu*	*Hans-Otto Walther*	*Tomás Caraballo*
10:50 - 11:30	José M. Arrieta	Tomás Caraballo	Hugo Leiva
11:30 - 12:10	Haomin Zhou	Wuchen Li	Jorge Sotomayor
12:10 - 14:30		Lunch	

Auditorium	Special Session on Nonlinear Dynamical Systems & Computational Dynamics		
Chairman	*Ma To Fu*	*Sergio M. Oliva Filho*	*Marcone Correa Pereira*
14:30 - 15:00	Sergio M. Oliva Filho	Andre Vicente	Ma To Fu
15:00 - 15:30	Javier López-de-la-Cruz	Luis Felipe Rivero	Jose Luis Sanchez
15:30 - 16:00	Junya Nishiguchi	Phillipo Lappicy	Jia-Yuan Dai
16:00 – 16:30	Coffee Break & Poster Session	Coffee Break & Poster Session	Coffee Break
16:30 – 17:00	Nicola Vassena	Marcone Correa Pereira	Juliana F. S. Pimentel
17:00 – 17:30	Adem Guengoer		Hildebrando M. Rodrigues

Room 5-101	Special Session on Elliptic Equations		
Chairman	*Raquel Lehrer*	*Liliane de Almeida Maia*	*Francisco O. de Paiva*
14:30 - 15:00	Liliane de Almeida Maia	Andres Ignacio Avila	Raquel Lehrer
15:00 - 15:30	Giovany M. Figueiredo	Flávio Almeida Lemos	Cristian Morales-Rodrigues
15:30 - 16:00	Marcelo F. Furtado	Francisco O. de Paiva	Nilson Costa Roberty
16:00 - 16:30	Coffee Break & Poster Session	Coffee Break & Poster Session	Coffee Break
16:30 - 17:00	Jefferson A. Santos	Jiazheng Zhou	Antoine Laurain
17:00 - 17:30	Gustavo Madeira	Leandro da Silva Tavares	

Room 5-002	Special Session on Linear Partial Differential Equations	
Chairman	*Alexandre Kirilov*	*Tiago Henrique Picon*
14:30 - 15:00	Tiago Henrique Picon	José Ruidival dos Santos Filho
15:00 - 15:30	Evandro R. da Silva	Alexandre Kirilov
15:30 - 16:00	Alexandre Arias Junior	Luciele Rodrigues Nunes
16:00 - 16:30	Coffee Break & Poster Session	Coffee Break & Poster Session
16:30 - 17:00	Camilo Campana	Eduardo Rosa
17:00 - 17:30	Wanderley Cerniauskas	Jamil Abreu

Room 5-103	Special Session on Ordinary and Functional Differential Equations		
Chairman	*Everaldo Bonotto*	*Jaqueline G. Mesquita*	*Xiaoying Han*
14:30 - 15:00	Jaqueline G. Mesquita	Everaldo Bonotto	Canceled
15:00 - 15:30	Canceled	Marielle Aparecida Silva	Hugo de La Cruz
15:30 - 16:00	Maria Carolina S. Mesquita	Fernanda A. da Silva	Jayme Vicente de Luca
16:00 - 16:30	Coffee Break & Poster Session	Coffee Break & Poster Session	Coffee Break
16:30 - 17:00	Ginnara Mexia Souto	Fernando G. de Andrade	Canceled
17:00 - 17:30	Xiaoying Han	Claudio Andrés Gallegos	

Room 5-004	Special Session on Dispersive Equations	
Chairman	*Marcia A. G. Scialom*	*Mahendra Panthee*
14:30 - 15:00	Fábio Natali	Adán J. Corcho Fernández
15:00 - 15:30	Chulkwang Kwak	Thiago Pinguello de Andrade
15:30 - 16:00	Marcio Cavalcante	José Raul Quintero
16:00 - 16:30	Coffee Break & Poster Session	Coffee Break & Poster Session
16:30 - 17:00	Mahendra Panthee	Marcia A. G. Scialom
17:00 - 17:30	Jaime Angulo	

Room 5-104	Special Session on Session on Conservation Laws and Transport Equations & Fluid Dynamics	
Chairman	*Gabriela Planas*	*Wladimir Neves*
14:30 - 15:00	Wladimir Neves	Cesar J. Niche
15:00 - 15:30	David A. Chipana Mollinedo	Leonardo Kosloff
15:30 - 16:00	Matheus C. dos Santos	Gabriela Planas
16:00 - 16:30	Coffee Break & Poster Session	Coffee Break & Poster Session
16:30 - 17:00	Anne Caroline Bronzi	Canceled

Coffee Area	Poster Session
10:20-10:50	Makson Sales Santos
10:20-10:50	Paulo N. Seminario Huertas
10:20-10:50	Rodiak N. Figueroa López
10:20-10:50	Wescley Bonomo

16:00 - 16:30	Ailton Rodrigues da Silva	Adeval Lino Ferreira
16:00 - 16:30	Giane Casari Rampasso	Eduardo Lima Oliveira
16:00 - 16:30	Jean Carlos Nakasato	Lucas Galhego Mendonça
16:00 - 16:30	Thiago Siqueira Ramos	Vladimir Angulo Castillo

	Social Events
18:00	**Happy Hour** (Água Doce Cachaçaria)
12:10	**Photo** (ICMC)
20:00	**Conference Banquet** (Café Sete)

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

2018 Chapter

List of Speakers

List of speakers **(ordered by last name)**

ICMC SUMMER MEETING on DIFFERENTIAL EQUATIONS

2018 Chapter

Sponsors

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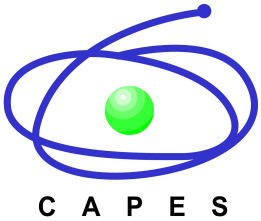

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