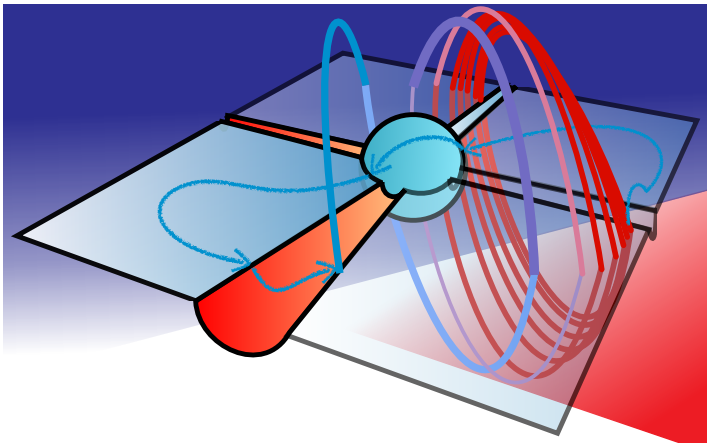


1 to 4
JULY

ICMC/USP and DM/UFSCar
São Carlos - SP
www.sisdin.com.br

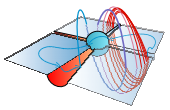
# X WORKSHOP
on Dynamical Systems
# 2019

# Book of Abstracts

Celebrating the 10th edition of

**Workshop on Dynamical Systems**

SUPPORT: CAPES FAPESP INCTMat ICMC USP SÃO CARLOS ufscar



# Welcome!

It is a pleasure to welcome you to the X Workshop on Dynamical Systems and to São Carlos. We hope you will take advantage of the stimulating scientific environment of this meeting, reestablish contact with friends and collaborators while having a pleasant stay here. If you encounter any difficulties during your stay, please feel free to contact any of us from the Organizing Committee.

## Scientific Committee

Clodoaldo Grotta Ragazzo (IME/USP)
Edson Vargas (IME/USP)
Jorge Sotomayor (IME/USP)
Ketty de Rezende (IMECC/UNICAMP)
Marco Antonio Teixeira (IMECC/UNICAMP)
Mário Jorge Dias Carneiro (UFJF/MG)

## Organizing Committee

Alex Rezende (DM/UFSCar)
Claudio Buzzi (IBILCE/UNESP)
Douglas Novaes (IMECC/UNICAMP)
Francisco Braun (DM/UFSCar)
Marcos Mota (ICMC/USP)
Regilene Oliveira (ICMC/USP)

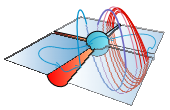
We are here to help you with anything!

## Address

Universidade de São Paulo
Instituto de Ciências Matemáticas e de Computação
Avenida Trabalhador São-Carlense, 400 - Centro
CEP: 13566-590 - São Carlos - São Paulo - Brasil

Universidade Federal de São Carlos
Departamento de Matemática
Rodovia Washington Luís, km 235 - SP-310 - C.P. 676
CEP: 13565-905 - São Carlos - São Paulo - Brasil

*E-mail:* xsisdin@icmc.usp.br



# General Information

## Transportation Between USP and UFSCar

There will be a bus available for the transportation between USP and UFSCar, more details will be given during the Workshop. You can also take a taxi (call to +55 16 3415 6005) or an Uber (using your cell phone's application).

## Meals and Refreshment

There are several restaurants on both campus. See the maps on the next two pages.

## Official Dinner

The official dinner will take place at **Café Sete Gastrobar**. The dinner cost is included on the registration fee. For non registered participants, tickets cost BRL 70,00 each.

## Health Emergencies

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

## Money Exchange

In case you need to exchange your money, there are places where you can do it. For more details, please contact the Organizing Committee.

## Smoking

Smoking is prohibited inside of USP and UFSCar buildings.

## Internet Access

Both the universities provide access to wireless internet connection via **eduroam**. Local Wi-Fi networks will be available during the Workshop.

## Maps

In the next two pages we present two maps, the first one is from USP and the second one form UFSCar.


Rodovia Washington Luiz
UFSCAR
Churrascaria Trevo (R37)
Churrascaria Tabajara (R36)
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
R. W. Cunha
Av. Trabalhador Sãocarlense
Al. das Hortências
Al. das Crisandálias
Av. das Azaléias
Av. Prof. Luis A. Oliveira
R. Antonio Blanco
R. Dna. Alexandrina
R. São Joaquim
R. Salomão Dibbo
R. 9 de Julho
R. Achile Bassi
R. Cezar Ricomi
Rodoviária
(Bus Station)
R. Jacinto Favoretto
R. Episcopal
R. Adolfo Cattani
R. Alfredo Lopes
R. Orlando Damiano
R. Tiradentes
R. 28 de Setembro
Av. São Carlos
Av. Dr. Carlos Botelho
R. Miguel Petrone
Rua Dr. Carlos de Camargo Salles
Bank of Brazil AG 6845-4
11h00m to 16h00m
MON to FRI
PAPELARIA CAASO
PRAÇA
BIBLIOTECA
ICMC-USP
(ZOOM UP AT THE BACK OF THIS PAGE)
Bank of Brazil AG 3062-7
11h00m to 16h00m
MON to FRI
R. Conselheiro João Alfredo
R. Dna. Maria Jacinta
R. Dr. Serafim Vieira de Almeida
Santa Casa
(Hospital)
R. Maestro João Seppe
R. Paulino Botelho de Abreu Sampaio
R. Paulino Botelho A. Sampaio
R. Princesa Isabel
R. Cap. Adão Pereira de Souza Cabral
Praça
XV de
Novembro
R. 15 de Novembro
Fitta Currency Exchange
9h30m to 17h30m
MON to FRI
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
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

# UFSCar São Carlos


### Administração

**1** Central de Serviços Terceirizados
**2** Coordenadoria de Comunicação Social ***CCS***
**3** Coordenadoria de Cursos a Distância
**4** Secretaria Geral de Gestão Ambiental e Sustentabilidade ***SGAS***
**5** Departamento de Almoxarifado ***DeAlm*** da ***ProAd***
**6** Departamento de Produção Gráfica ***DePG***
**7** Departamento de Transporte ***DeTrans*** da ***PU*** | Seção de Vigilância ***SeVig*** da ***PU***
**8** Divisão de Registro de Diplomas ***DiRD*** da ***ProAd***
**9** Edifício Anexo à Reitoria
**10** EdUFSCar ***Editora***
**11** EdUFSCar ***Livraria***
**12** Prefeitura Universitária ***PU*** Escritório de Desenvolvimento Físico ***EDF***
**13** Pró-Reitoria de Assuntos Comunitários e Estudantis ***ProACE***
**14** Pró-Reitoria de Gestão de Pessoas **ProGPe**
**15** Pró-Reitoria de Graduação ***ProGrad*** | Pró-Reitoria de Extensão ***ProEx***
**16 *Reitoria*** | Pró-Reitoria de Administração ***ProAd*** | Procuradoria Jurídica ***PJ*** | Pró-Reitoria de Pós-Graduação ***ProPG*** | Pró-Reitoria de Pesquisa ***ProPq*** | Secretaria Geral de Relações Internacionais ***SRInter*** |Departamento de Compras ***DeCom*** da ***ProAd*** | Departamento Financeiro ***DeFin*** da ***ProAd***
**17** Secretaria Geral de Educação a Distância ***SEaD***
**18** Unidade de Gestão de Resíduos ***UGR***

### Apoio Administrativo e Acadêmico

**1** Anfiteatro Bento Prado Júnior | Sala de Apoio
**2** Anfiteatro da Reitoria
**3** Biblioteca Comunitária ***BCo*** | Auditórios 1, 2 e 3 da ***BCo***
**4** Centro de Convivência Sul | Athenas Paulista ***Venda de passes***
**5** Departamento de Assistência Médica e Odontológica ***DeAMO*** | Departamento de Serviço Social ***DeSS***
**6** Divisão de Controle Acadêmico ***DiCA***
**7** Espaço Cultural
**8** Espaço de Estudo | Balcão de Orientações de Estudo ***ProEstudo***
**9** Fundação de Apoio Institucional ***FAI - UFSCar***
**10** Ginásio de Esportes
**11** Laboratório Aberto de Interatividade ***LAbI***
**12** Moradia Estudantil | Espaço Vivência
**13** Núcleo de Formação de Professores - Blocos A e C
**14** Núcleo Multidisciplinar e Integrado de Estudos, Formação e Intervenção em Economia Solidária **NuMI - EcoSol**
**15** Observatório
**16** Pavilhão de Ginástica | Ginasinho
**17** Rádio UFSCar
**18** Restaurante Universitário ***RU***
**19** Salas de Aula ***AT1*** | Babilônia I
**20** Salas de Aula ***AT2*** | Babilônia II | Auditório do ***CECH***
**21** Salas de Aula ***AT4***
**22** Salas de Aula ***AT5***
**23** Salas de Aula ***AT6 e AT9***
**24** Salas de Aula ***AT7***
**25** Salas de Aula ***AT8***
**26** Salas de Aula **AT10**
**27** Secretaria Geral de Informática ***SIn***
**28** Tablado (Restaurante)
**29** Teatro Florestan Fernandes
**30** Unidade de Atendimento à Criança ***UAC***

### Centro de Educação e Ciências Humanas

**1** Departamento de Artes e Comunicação ***DAC***
**2** Departamento de Ciências Sociais ***DCSo***
**3** Departamento de Educação Especial
**4** Departamento de Filosofia e Metodologia das Ciências ***DFMC***
**5** Departamento de Letras ***DL***
**6** Departamento de Metodologia de Ensino ***DME***
**7** Departamento de Psicologia ***DPsi***
**8** Departamento de Sociologia ***DS***
**9** Diretoria do ***CECH*** | Departamento de Ciência da Informação ***DCI*** | Departamento de Educação ***DEd*** | Arquivo de História Contemporânea ***AHC*** | Portal dos Professores | Neab | Niasi | Núcleo de Pesquisa e Documentação | **10** Laboratório de Educação Especial - DPsi.
**11** Laboratório de Musicalização do ***DAC***
**12** Laboratório Integrado de Documentação e Estatísticas Políticas e Sociais **LIDEPS**
**13** Núcleo de Extensão UFSCar ú Escola
**14** Sala de Ensaio da Orquestra
**15** Teatro de Bolso

### Centro de Ciências Exatas e de Tecnologia

**1** Auditório José Carlos Nogueira do ***DQ***
**2** Centro de Caracterização e Desenvolvimento de Materiais ***CCDM***
**3** Centro de Pesquisa em Processos e Materiais Avançados para Indústria do Petróleo
**4** Departamento de Computação ***DC***
**5** Departamento de Estatística ***DEs***
**6** Departamento de Engenharia Civil ***DECiv***
**7** Departamento de Engenharia de Materiais ***DEMa***
**8** Departamento de Engenharia Mecânica - Departamento de Engenharia Elétrica ***DEM-DEE***
**9** Departamento de Engenharia de Produção ***DEP***
**10** Departamento de Engenharia Química ***DEQ***
**11** Departamento de Matemática ***DEM***
**12** Departamento de Química ***DQ***
**13** Depósito de Produtos Químicos do ***DQ***
**14** Diretoria do ***CCET*** | Departamento de Física ***DF***
**15** Laboratório de Biopolímeros do ***DEMa***
**16** Laboratório de Microscopia Eletrônica
**17** Laboratório de Destilação do ***DQ***
**18** Laboratório Interdisciplinar de Eletroquímica e Cerâmica ***LIEC*** do ***DQ***
**19** Laboratório de Engenharia do Produto do ***DEP***
**20** Laboratório de Ensino de Química do ***DQ***
**21** Laboratório de Física e Química do ***CCET***
**22** Laboratório de Materiais Vítreos do ***DEMa***
**23** Laboratório ***NET*** | Pré-moldados
**24** Laboratório de Operações Unitárias do ***DEQ***
**25** Laboratório de Reciclagem do ***DEMa***
**26** Laboratórios de Pesquisa do ***DECiv***
**27** Laboratório de Processos Catalíticos e Biotecnológicos ***DEQ***
**28** Laboratório de Simulação e Projetos de Unidades Produtivas ***PSPLAB/DEP***
**29** Laboratório de Topografia e Estradas
**30** Núcleo de Laboratórios de Ensino à Engenharia ***NuLEEn***
**31** Núcleo de Serviços do ***DQ***
**32** Oficina Eletrônica do ***CCET***

### Centro de Ciências Biológicas e da Saúde

**1** Ambulatório
**2** Anexos II e III do ***DEBE***
**3** Biotério Central
**4** Casa de Vegetação do ***DB***
**5** Centro de Pesquisa Integrada da Biodiversidade Tropical
**6** Unidade de Simulação da Prática Profissional em Saúde ***USPPS***
**7** Departamento de Botânica ***DB***
**8** Departamento de Ciências Fisiológicas ***DCF***
**9** Departamento de Ecologia e Biologia Evolutiva ***DEBE***
**10** Departamento de Educação Física e Motricidade Humana ***DEFMH***
**11** Departamento de Enfermagem ***DEnf***
**12** Departamento de Fisioterapia ***DFisio***
**13** Departamento de Genética e Evolução ***DGE***
**14** Departamento de Gerontologia GERo
**15** Departamento de Hidrobiologia ***DHb***
**16** Departamento de Medicina ***DMed***
**17** Departamento de Medicina II DMed
**18** Departamento de Morfologia e Patologia ***DMP***
**19** Departamento de Terapia Ocupacional ***DTO***
**20** Diretoria do ***CCBS***
**21** Gestão Ambiental - Biotecnologia
**22** Jardim Experimental
**23** Laboratório de Anatomia
**24** Laboratório do ***DB***
**25** Unidade Saúde-Escola ***USE***

# Sponsors

The **X Workshop on Dynamical Systems** wishes to thank the following organizations for sponsoring this event.

Universidade de São Paulo
Instituto de Ciências Matemáticas e de Computação
www.icmc.usp.br

Universidade Federal de São Carlos
Departamento de Matemática
www.dm.ufscar.br

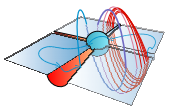
INCTmat
Instituto Nacional de Ciência e Tecnologia de Matemática
inctmat.impa.br

The **X Workshop on Dynamical Systems** wishes to thank the following organizations for providing the financial support for the realization of this meeting.

FAPESP
Fundação de Amparo à Pesquisa do Estado de São Paulo
www.fapesp.br

CAPES
Coordenação de Aperfeiçoamento de Pessoal de Nível Superior
www.capes.gov.br

# Contents



# The Workshop on Dynamical Systems

The tenth edition of the Workshop on Dynamical Systems (WDS) will be held in the Instituto de Ciências Matemáticas e de Computação of the University of São Paulo (ICMC/USP) and in the Department of Mathematics of the Universidade Federal de São Carlos (DM/UFSCar), in São Carlos-SP, in July 1 to 4, 2019.

The main goal of the WDS is joining researchers and graduate students which dedicates their research to the Qualitative and Geometric Theory of Differential Equations, with the purpose to form and intensify the permanent and productive link among researchers and students.

The first edition of the WDS was held in 2009 at UNICAMP, Campinas-SP. Since then other editions took place in Goiânia-GO, Presidente Prudente-SP, São Paulo-SP, Itajubá-MG, Pirenópolis-GO, and São Bernardo do Campo-SP.

Traditionally, talks and minicourses deal with the following topics: Reversible Dynamical Systems, Polynomial Vector Fields, Piecewise Dynamical Systems, Topics on the Markus-Yamabe Problem, Geometrical Theory of Singular Perturbation, Normal Forms, Differential Equations of Geometry and Singularities.

In what follows we present the official picture of each one of the previous WDS editions.


**Figure 1:** I Workshop on Dynamical Systems: UNICAMP – 2009.

**Figure 2:** II Workshop on Dynamical Systems: UNICAMP – 2010.

**Figure 3:** III Workshop on Dynamical Systems: UFG – 2011.

**Figure 4:** IV Workshop on Dynamical Systems: IME/USP – 2012.

**Figure 5:** V Workshop on Dynamical Systems: FCT/UNESP – 2013.


**Figure 6:** VI Workshop on Dynamical Systems: UNICAMP – 2014.

**Figure 7:** VII Workshop on Dynamical Systems: UNIFEI – 2015.

**Figure 8:** VIII Workshop on Dynamical Systems: UFG-Pirenópolis – 2016.


**Figure 9:** IX Workshop on Dynamical Systems: UFABC – 2017.

# Program

| X WSD July 1-4,2019 | Monday July 1st | Tuesday July 2nd | Wednesday July 3rd | Thursday July 4th |
|---|---|---|---|---|
| 9h00 - 9h30 | | Opening | D. Smania | M. Jeffrey |
| 9h30 - 10h20 | | J. Llibre | | D. Pagano |
| 10h20 - 10h40 | | COFFEE | COFFEE | COFFEE |
| 10h40 - 11h05 | | I. Meza-Sarmiento | N. de Paulo | R. Martins |
| 11h05 - 11h30 | | C. Pessoa | F. Dias | B. Alarcón |
| 11h30 - 11h55 | | D. Tonon | J. Sotomayor | R. Garcia |
| 11h55 - 12h20 | | P. Cardin | | |
| 12h20 - 14h10 | | LUNCH | LUNCH | LUNCH |
| 14h10 - 15h00 | | T. M-Seara | PhD Session | V. Carmona |
| 15h00 - 15h25 | | | Poster | F. Sánchez |
| 15h25 - 15h50 | | R. Euzébio | Interaction time, Poster and COFFEE | D. Novaes |
| 15h50 - 16h15 | | D. Lima | | |
| 16h15 - 16h35 | | COFFEE | | COFFEE |
| 16h35 - 17h00 | Registration | I. Zeli | | D. Smania |
| 17h00 - 17h25 | | G. Ponce | T. M-Seara | |
| 17h25 - 18h15 | | F. Tal | | |
| 19h45 - 23h00 | | | DINNER | |

| CAPTION |
|---|
| Plenary (50 min) |
| Talk (30 min) |
| Minicourse 1 (1h 20min) |
| Minicourse 2 (1h 20min) |

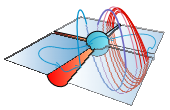
**Place of the Activities**

Monday (July 1st)
ICMC/USP (Entrance Hall - Auditorium Prof. Fernão Stella de Rodrigues Germano)

Tuesday (July 2nd)
ICMC/USP (Auditorium Prof. Fernão Stella de Rodrigues Germano)

Wednesday (July 3rd)
*Morning:* DM/UFSCar (Mathematics Department's Auditorium)
*Afternoon:* ICMC/USP (Auditorium Prof. Fernão Stella de Rodrigues Germano)

Thursday (July 4th)
*Morning:* DM/UFSCar (Mathematics Department's Auditorium)
*Afternoon:* ICMC/USP (Auditorium Prof. Fernão Stella de Rodrigues Germano)

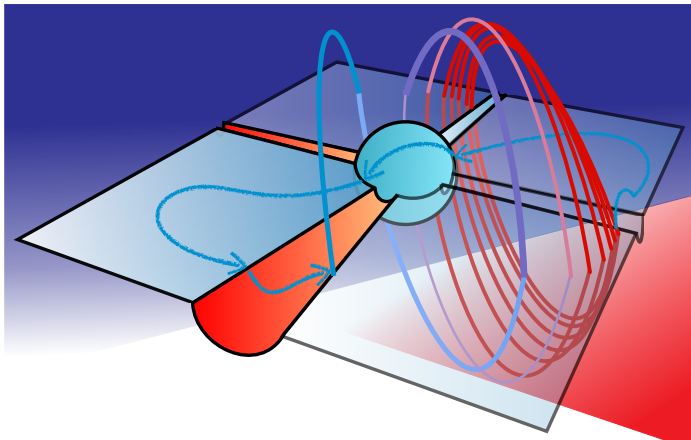


# List of Participants

Alacyr José Gomes (UFG)
Alex Carlucci Rezende (DM-UFSCar)
Alfredo Manuel Jara Grados (UFABC)
Ana Livia Rodero (IBILCE - UNESP)
Ana Maria Alves da Silva (UFG)
Ana Maria Travaglini (ICMC-USP)
Andre do Amaral Antunes (IBILCE - UNESP)
Andreé Ricardo Ríos Baylón (ICMC-USP)
Antonio Martins Alves Veloso dos Santos (ICMC-USP)
Begoña Alarcón Cotillas (UFF)
Benito Frazão Pires (USP - Ribeirão Preto)
Bruna Oréfice Okamoto (DM-UFSCar)
Bruno Rodrigues de Freitas (UFG)
Caio Augusto Santos Magalhães (UFG)
Cícero Rumão Gonçalves de Sousa Junior (UFG)
Claudio Aguinaldo Buzzi (IBILCE - UNESP)
Claudio Gomes Pessoa (IBILCE - UNESP)
Dahisy Valadão de Souza Lima (UFABC)
Daniel Juan Pagano (UFSC)
Daniel Smania Brandao (ICMC-USP)
Dayane Ribeiro Cruz (IMECC - UNICAMP)
Devis Ordoño Vilca (DM-UFSCar)
Douglas Duarte Novaes (IMECC - UNICAMP)
Durval José Tonon (UFG)
Ewerton Rocha Vieira (UFG)
Fabio Armando Tal (IME-USP)
Fabio Scalco Dias (UNIFEI)
Fernando Fernández-Sánchez (Universidad de Sevilla)
Filipe Balduino Pires Fernandes (DM-UFSCar)
Francisco Braun (DM-UFSCar)
Gabriel Alexis Rondón Vielma (IMECC - UNICAMP)
Gabriel Ferreira da Silva (IMECC - UNICAMP)
Gabriel Ponce (IMECC - UNICAMP)
Gabriel Silva Lucidio (DM-UFSCar)
Guilherme Tavares da Silva (IMECC - UNICAMP)
Hugo Leonardo da Silva Belisário (IFG)
Hugo Leonardo Salomão Monteiro (EESC-USP / UFSCar)
Ingrid Sofia Meza Sarmiento (DM-UFSCar)
Iris de Oliveira Zeli (ITA)
Iván Sánchez (UAB-Barcelona)

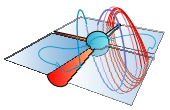
Jarne Donizetti Ribeiro (IBILCE - UNESP)
Jaume Llibre Saló (UAB-Barcelona)
Jean Venato Santos (UFU)
Jeferson Cassiano (UFABC)
Jéfferson Luiz Rocha Bastos (IBILCE - UNESP)
Joaby de Souza Jucá (UFG)
João Carlos da Rocha Medrado (UFG)
Jorge Manuel Sotomayor Tello (IME-USP)
Jose Humberto Bravo Vidarte (UNIFEI)
José Régis Azevedo Varão Filho (IMECC - UNICAMP)
Kamila da Silva Andrade (UFG)
Ketty Abaroa de Rezende (IMECC - UNICAMP)
Leonardo Pereira Costa da Cruz (DM-UFSCar)
Luan Lima da Silva (UFG)
Lucas Queiroz Arakaki (IBILCE - UNESP)
Luci Any Francisco Roberto (IBILCE - UNESP)
Luis Felipe Narvaez Plaza (UFG)
Luiz Fernando Gonçalves (IBILCE - UNESP)
Marcelo Messias (UNESP - Presidente Prudente)
Marco Antonio Teixeira (IMECC - UNICAMP)
Marcos Coutinho Mota (ICMC-USP)
Mariana Queiroz Velter (UFG)
Marisa dos Reis Cantarino (IMECC - UNICAMP)
Maurício Firmino Silva Lima (UFABC)
Mayk Joaquim dos Santos (UFG)
Mike Jeffrey (University of Bristol)
Míriam Garcia Manoel (ICMC-USP)
Naiara Vergian de Paulo Costa (UFSC - Blumenau)
Nancy Carolina Chachapoyas Siesquén (UNIFEI)
Nathanni Vieira de Pádua (UFG)
Neilson Castro Soares (DM-UFSCar)
Oscar Alexander Ramirez Cespedes (UFV)
Otávio Henrique Perez (IBILCE - UNESP)
Otávio Marçal Leandro Gomide (IMECC - UNICAMP)
Patrícia Tempesta (UFSJ)
Paulo Henrique Reis Santana (IBILCE - UNESP)
Paulo Ricardo da Silva (IBILCE - UNESP)
Pedro Henrique Takemura Feitosa da Silva (DM-UFSCar)
Pedro Toniol Cardin (UNESP - Ilha Solteira)
Rafael de Oliveira Moura (ICMC-USP)
Raul Felipe Appis (DM-UFSCar)
Regilene Delazari dos Santos Oliveira (ICMC-USP)
Ricardo Miranda Martins (IMECC - UNICAMP)
Rodrigo Donizete Euzébio (UFG)
Ronaldo Alves Garcia (UFG)
Rony Cristiano (UFG)

Samuel Krüger (IMECC - UNICAMP)
Tere M-Seara (Universitat Politècnica de Catalunya)
Tiago Carvalho (USP - Ribeirão Preto)
Tiago Emilio Siller (IMECC - UNICAMP)
Victoriano Carmona Centeno (Universidad de Sevilla)
Wilker Thiago Resende Fernandes (UFSJ)
Yovani Adolfo Villanueva Herrera (UFG)



# X WORKSHOP
on Dynamical Systems
# 2019

## Plenaries



# Forcing theory applications for homeomorphisms of the closed annulus

**Fabio Armando Tal**

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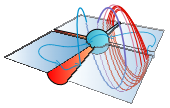
**Abstract:** We will present some applications of forcing theory for the study of rotation sets of homeomorphisms of the closed annulus preserving boundary components and orientation. We will show the strong version of Boyland's conjecture holds, that is, that if such a homeomorphism preserves area and its rotation interval is not trivial, then the rotation number of the lebesgue measure lies in the interior of the rotation interval. We will also show that, if $f$ is area preserving, then every rotation vector in the rotation set is realized by a compact invariant set, extending a result by Le Calvez previously known for diffeomorphisms.
Joint work with Jonathan Conejeros.



# On the complete integrability of the N-dimensional differential systems

**Jaume Llibre**

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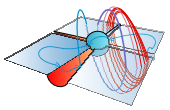
**Abstract:** First we present some new results on the complete integrability of the N-dimensional differential systems, based on the Nambu bracket and the Jacobi multiplier.
Second we provide two improvements to the classical Jacobi Theorem on the complete integrability of the N-dimensional differential systems having N-2 independent first integrals and a Jacobi multiplier.
Third we present new results on the complete integrability of the 3-dimensional differential Lotka-Volterra differential systems and on their Jacobi multipliers.



# Sobre o trabalho de Maurício Peixoto em sistemas dinâmicos

**Jorge Sotomayor**

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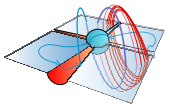
**Resumo:** Será abordado o trabalho de Peixoto em Estabilidade Estrutural e sua repercussão na Teoria Qualitativa das Equações Diferenciais da Geometria Clássica e de Bifurcações. Problemas abertos por essa interação serão discutidos.



# The ghosts of departed quantities in switches and transitions

**Mike Jeffrey**

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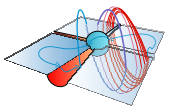
**Abstract:** Transitions between steady dynamical regimes in diverse applications are often modeled using discontinuities, but doing so introduces problems of uniqueness. No matter how quickly a transition occurs, its inner workings can affect the dynamics of the system significantly. Here we discuss the way transitions can be reduced to discontinuities without trivializing them, by preserving so-called hidden terms. We review the fundamental methodology, its motivations, and where their study seems to be heading. We derive a prototype for piecewise-smooth models from the asymptotics of systems with rapid transitions, sharpening Filippov's convex combinations by encoding the tails of asymptotic series into nonlinear dependence on a switching parameter. We present a few examples that illustrate the impact of these on our standard picture of smooth or only piecewise-smooth dynamics.



# Bilhares elípticos e poligonais: resultados clássicos e recentes

**Ronaldo Alves Garcia**

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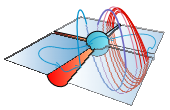
**Resumo:** Nesta palestra iremos abordar bilhares (elípticos e poligonais) e descrever lugares geométricos associados as órbitas periódicas. Descrevemos resultados clássicos devidos a Poncelet, Darboux, Chasles e recentes devidos a S. Tabachnikov, R. Schwartz, O. Romaskevich e outros.



# A common and useful expression for all Poincaré half-maps in planar linear systems: construction via inverse integrating factors

**Victoriano Carmona Centeno**

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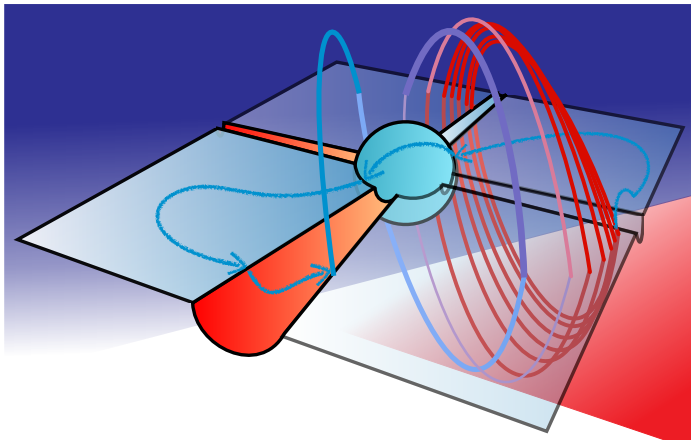
**Abstract:** The analysis of Poincaré half-maps in piecewise linear systems is usually based on the explicit integration of the flow in every linearity zone with the intention of obtaining a complete return map. This procedure causes two principal problems: the need to distinguish many cases depending on the spectra of the matrices and the nonlinear appearance of the flight time in the obtained expressions.
A way to override these two negative effects of the explicit integration is, obviously, to avoid this integration. Of course that if we do not integrate the system then we will not obtain explicit expressions for the orbits but, fortunately, the only important points of the orbit for Poincaré half maps are those that are located at the switching manifold, that is, the initial and final points of every piece of orbit. Therefore, the explicit expression of the orbit together with the flight time are completely irrelevant to the Poincaré half-map.
The question then is if there is any other way to get Poincaré half-maps without the explicit integration of the flow. The answer is yes and an alternative and fruitful way rest on inverse integrating factors.
In this talk we will explain how to use inverse integrating factors to obtain a common and useful expression to describe all Poincaré half-maps to straight lines for planar linear systems.
Joint work with Fernando Fernández-Sánchez and Elisabeth García-Medina.



# X WORKSHOP
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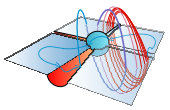
## Talks



# Global dynamics for planar vector fields with a star node and homogeneous nonlinearities

**Begoña Alarcón**

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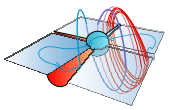
**Abstract:** We study the global dynamics of vector fields of the form $u' = au + Q(u)$, where $a > 0$ and $Q(u)$ is a planar homogeneous polynomial vector field. We discuss the number and stability of equilibrium points, both in the plane and in the circle at infinity in the Poicaré compactication. We obtain conditions for the existence of a globally attracting poly-cycle, thus extending previous results on the existence of limit cycles. A more detailed analysis is done for symmetric vector fields.
Joint work with Isabel Labouriau and Sofia Castro.



# Melnikov like function for 3-dimensional piecewise smooth vector fields

**Claudio Pessoa**

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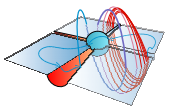
**Abstract:** We consider a 3–dimensional piecewise smooth vector fields with two zones separated by a hyperplane $\Sigma$ which admits an invariant hyperplane $\Omega$ transversal to $\Sigma$ containing a period annulus $A$ fulfilled by crossing periodic solutions. For small discontinuous perturbations of these systems we develop a Melnikov like function to control the persistence of periodic solutions contained in $A$. We provide normal forms for the piecewise linear case. Finally we apply the Melnikov like function to study the number of limit cycles that bifurcate from $A$ by small perturbations of the given normal forms.



# Conley theory for $S^1$-isolated invariant sets

**Dahisy Lima**

*Universidade Federal do ABC*

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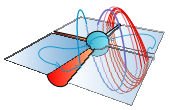
**Abstract:** In this talk, we make use of Conley Index Theory to capture the connections between $S^1$-critical manifolds of a Morse-Bott flow, as well as periodic orbits of a Morse-Smale flow. Our goal is to obtain results on dynamical cancellations of these types of $S^1$-isolated invariant sets in a smooth flow. In order to achieve that, we make use of a rich algebraic-topological tool which provides much insight into dynamical properties of the system.



# Open problems in sliding mode control systems with two switching boundaries

**Daniel Juan Pagano**

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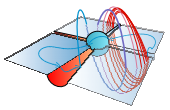
**Abstract:** Piecewise smooth dynamical systems with discontinuous right-hand side (Filippov systems) play an important role in the modeling of many physical, biological, mechanical and engineering applications and present interesting and complex mathematical questions.
In particular, the well-established Filippov convexification method provides a powerful and useful tool to establish what to do when trajectories reach a codimension 1 manifold of discontinuity. However, it is still not fully understood what happens when trajectories have to move on the intersection of two smooth manifolds (co-dimension 2 switching boundary).
In this talk, we discuss some open problems in sliding mode control (SMC) systems related to sliding motion on a switching boundary $\Sigma$ of co-dimension 2. Some case studies from real applications allow us to illustrate the methodology developed to analyze this kind of systems.



# The Lum-Chua conjecture revisited

**Douglas D. Novaes**

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*Universidade Estadual de Campinas*

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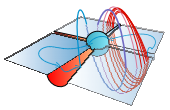
**Abstract:** In this talk, using the theory of inverse integrating factor, we provide a new simple proof for the Lum-Chua's conjecture, which says that a continuous planar piecewise linear differential system with two zones separated by a straight line has at most one limit cycle. In addition, we prove that if this limit cycle exists, then it is hyperbolic and its stability is characterized in terms of the parameters.



# Campos lineares por partes em $\mathbb{R}^2$ e $\mathbb{R}^3$

**Durval José Tonon**

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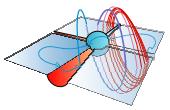
**Resumo:** Apresentaremos alguns resultados sobre estabilidade assintótica e cotas para ciclos limite para campos lineares por partes em $\mathbb{R}^2$ e $\mathbb{R}^3$.



# $Z_2$-symmetric planar polynomial Hamiltonian systems of degree 3 with nilpotent centers

**Fabio Scalco Dias**

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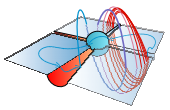
**Abstract:** In this work we will present the normal forms and the global phase portraits in the Poincaré disk of all $\mathbb{Z}_2$-symmetric planar polynomial Hamiltonian systems of degree 3 having a nilpotent center at the origin.
Joint work with Jaume Llibre and Claudia Valls.



# A common and useful expression for all Poincaré half-maps in planar linear systems: some relevant results

**Fernando Fernández-Sánchez**

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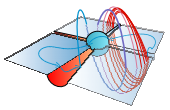
**Abstract:** In a previous talk entitled "A common and useful expression for all Poincaré half-maps in planar linear systems: construction via inverse integrating factors", given by Prof. V. Carmona, a nice expression has been constructed to manage Poincaré half-maps in linear systems. Its principal virtues are to remove the nonlinear appearance of the flight time and to collect, in just one implicit equation, all the cases that may appear due to the different spectra of matrices of linear systems. However, beyond these two important benefits, this expression based on inverse integrating factors is able to give much more information.
In this talk, it is time to show some relevant results and properties of Poincaré half-maps in linear systems, that can be easily obtained from the previously mentioned common expression. Some of the considered subjects will be, for instance, properties of first and second order derivatives of these half-maps, their series expansions and analyticity, the recovery of the flight time by means of a new common expression and the approach to half-maps as orbits of a particular planar differential system.
Joint work with Victoriano Carmona and Elisabeth Garcia-Medina.



# Leafwise equicontinuity and ergodic implications

**Gabriel Ponce**

*Instituto de Matemática, Estatística e Computação Científica*
*Universidade Estadual de Campinas*

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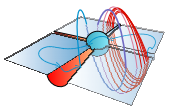
**Abstract:** In this talk we will address, and present substantial progresses on, some opens problems in the area of smooth ergodic theory, concerning the occurrence of strong ergodic properties for partially hyperbolic systems with some type of controlled behavior along its center direction.
The main goal is to present recent new techniques to approach these problems by finding a system of leafwise invariant metrics associated to the dynamics and then, applying recent results on the ergodic rigidity of weakly leafwise rigid actions.



# Quadratic slow-fast systems on the plane

**I.S.Meza-Sarmiento**

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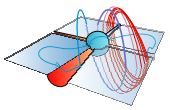
**Abstract:** In this talk singularly perturbed quadratic polynomial differential systems

$$\varepsilon \dot{x} = P_\varepsilon(x,y) = P(x,y,\varepsilon), \quad \dot{y} = Q_\varepsilon(x,y) = Q(x,y,\varepsilon)$$

with $x, y \in \mathbb{R}, \varepsilon \geqslant 0$ and $(P_\varepsilon, Q_\varepsilon) = 1$ for $\varepsilon > 0$, are considered. We prove that there are 10 classes of affine equivalence for these systems. We describe the dynamics of these 10 classes on the Poincaré disc when $\varepsilon = 0$. For $\varepsilon > 0$, we classify the possible finite and infinite singularities. We proved a kind of "Fenichel theorem". More specifically, by combining the slow and the fast dynamics with the dynamics at infinity, we describe the possible elliptic, hyperbolic, and parabolic sectors for the singularities at $\mathbb{S}^1$ (the equator of the Poincaré sphere). Moreover, when the critical manifold is normally hyperbolic we obtain algebraic invariants that allow us to describe globally the dynamics for $\varepsilon > 0$ small. In fact, when the critical manifold is a hyperbola we obtain 33 possible (and realizable) distinct phase portraits and when it is formed by two straight lines we get 11 possible (and realizable) distinct phase portraits on the Poincaré disc.
Joint work with R. Oliveira (ICMC-USP) and P.R. da Silva (IBILCE-UNESP).



# Bifurcation diagram of a simple two-fold cycle of planar Filippov systems

**Iris de Oliveira Zeli**

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**Abstract:** Generic bifurcation theory was classically well developed for smooth differential systems, establishing results for $k$-parameter families of planar vector fields. In the present work we focus on a qualitative analysis of 2-parameter families, $Z_{\alpha,\beta}$, of planar Filippov systems assuming that $Z_{0,0}$ presents a codimension-two minimal set. Such object, named elementary simple two-fold cycle, is characterized by a regular trajectory connecting a visible two-fold singularity to itself, for which the second derivative of the first return map is nonvanishing. We analyzed the codimension-two scenario through the exhibition of its bifurcation diagram.
Joint work with D. D. Novaes and M. A. Teixeira (IMECC/UNICAMP).

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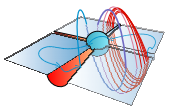

# Hamiltonian dynamics and the existence of transverse foliations

**Naiara V. de Paulo**

*Universidade Federal de Santa Catarina*

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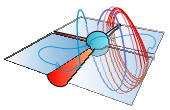
**Abstract:** Several phenomena in nature can be modeled by two-degree-of-freedom Hamiltonian systems. In this regard, global surfaces of section and systems of transverse sections have been used as tools for studying the dynamics restricted to energy levels of the Hamiltonian function. Roughly speaking, a system of transverse sections is a singular foliation of the energy level whose singular set is formed by finitely many periodic orbits and whose regular leaves are transverse to the Hamiltonian vector field. The Hamiltonian flow determines transition maps between some regular leaves of a system of transverse sections and such maps may provide valuable information about the dynamics on the energy level, such as the multiplicity of periodic orbits and homoclinics. In this talk I will present some results on this subject in collaboration with Pedro Salomao (University of São Paulo). If time permits, I will also discuss results on the existence of systems of transverse sections applied to classical Hamiltonian problems, namely the Euler problem of two fixed centers and the Henon-Heiles Hamiltonian, which are works in progress with Pedro Salomao and Umberto Hryniewicz (Federal University of Rio de Janeiro), and with Alexsandro Schneider (Unicentro) and Andre Vanderlinde (Federal University of Santa Catarina), respectively.



# Uma abordagem da teoria geométrica das perturbações singulares à simetria

**Pedro Toniol Cardin**

*Universidade Estadual Paulista*

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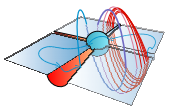
**Resumo:** Nesta apresentação iremos explorar algumas propriedades de simetria em sistemas dinâmicos rápido-lento singularmente perturbados. Seguindo o ponto de vista da teoria de Fenichel sobre a persistência de variedades compactas normalmente hiperbólicas, nossa principal questão é saber como as propriedades de simetria são afetadas por perturbações singulares. Ilustramos essa abordagem com alguns exemplos.



# The dynamics of the Ricci flow in homogeneous manifolds

**Ricardo M. Martins**

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*Universidade Estadual de Campinas*

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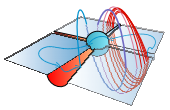
**Abstract:** Recently, methods of dynamical systems theory have been applied to various problems of differential geometry to study the evolution of flows in compact manifolds. In particular, a related technique was used to demonstrate the Poincaré conjecture. In this talk will be presented a technique that allows to describe the Einstein metrics for homogeneous manifolds using dynamical properties of the system of differential equations whose solution gives the Ricci flow. The focus will be on homogeneous manifolds of isotropy 2 and and also for flag manifolds.



# Invariant manifolds for some $3D$ polynomial differential systems

**Rodrigo Donizete Euzébio**

*Instituto de Matemática e Estatística - Universidade Federal de Goiás*

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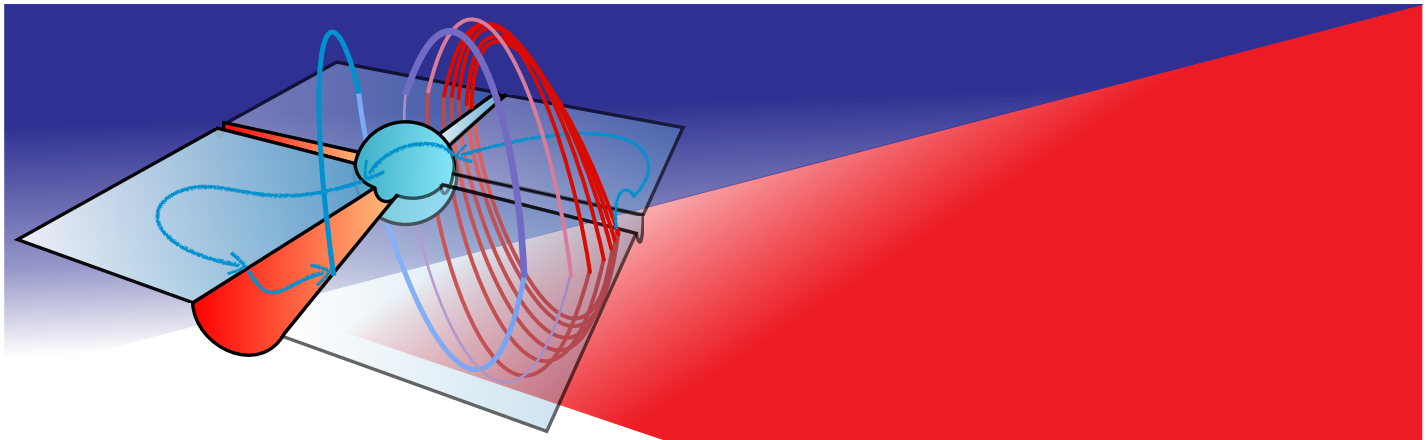
**Abstract:** In this talk we present some results concerning the existence and shape of bi-dimensional manifolds for piecewise smooth vector fields in dimension three. By applying a small piecewise smooth perturbation of a linear differential equation filled by periodic orbits we observe the bifurcation of some objects as spheres, cylinders and tori. The approach is based on the averaging theory. We finish the talk by presenting two concrete examples of the results.



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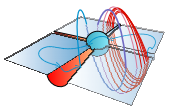
# Minicourses



# Comportamento genérico: pontos de vista topológico e da teoria da medida

**Daniel Smania**

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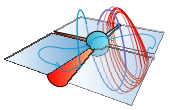
**Resumo:** Um sistema dinâmico, discreto ou contínuo, pode ter um comportamento muito complicado. Em geral não é possível descrever a evolução de todas as suas órbitas. Assim, muitas vezes se busca compreender a "maioria" das órbitas, seja do ponto de vista topológico (um conjunto residual de pontos) ou do ponto de vista da teoria da medida (a menos de um subconjunto de medida nula).
O objetivo desta série de duas palestras é oferecer aos estudantes uma introdução a esta abordagem no estudo dos sistemas dinâmicos, através de uma série de exemplos bem-sucedidos de sua aplicação. Incluiremos exemplos tanto de sistemas dinâmicos discretos, como em dinâmica unidimensional e em dimensão finita, como contínuos, como o fluxo de Lorenz.



# Shilnikov orbits unfolded by Hopf-zero singularities

**Tere M-Seara**

*Universitat Politècnica de Catalunya*

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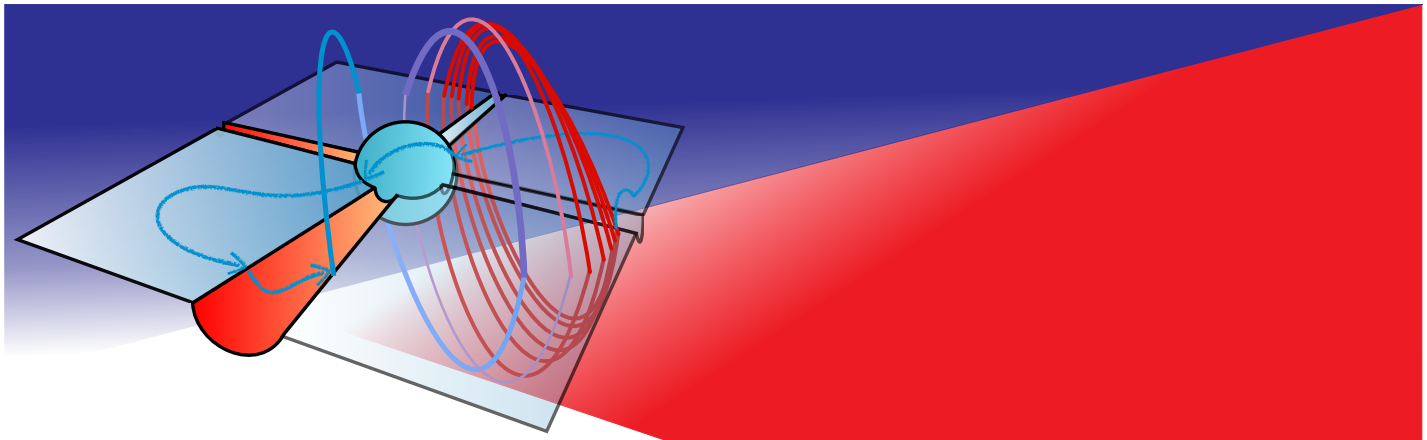
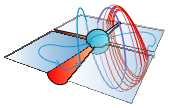
**Abstract:** The so-called Hopf-zero singularity consists in a vector field in dimension 3 having the origin as a critical point, with a zero eigenvalue and a pair of conjugate purely imaginary eigenvalues. If one considers conservative (i.e. one-parameter) unfoldings of such singularity, one can see that the truncation of the normal form at any order possesses two saddle-focus critical points whose stable and unstable manifolds (one and two-dimensional respectively) coincide along a one- and a two-dimensional heteroclinic connection. The same happens for non-conservative (i.e. two-parameter) unfoldings when the parameters lie in a certain curve.
However, when one considers the whole vector field, one expects these heteroclinic connections to be destroyed. This fact can lead to the birth of a homoclinic connection to one of the critical points, producing thus a Shilnikov bifurcation.
In this course we will prove that these bifurcations occur in generic unfoldings of some Hopf-zero singularities.
We will need to show that the heteroclinic connections are destroyed and this requires to deal with exponentially small phenomena. Then we will show that, the system has homoclinic orbits to the critical points.



# X WORKSHOP
on Dynamical Systems
# 2019

## PhD Session



# Critical periods of reversible Darboux linearizable isochronous centers

**Iván Sánchez**

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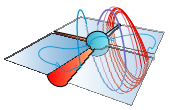
**Abstract:** A well-known problem in dynamical systems is the study of ciclicity, which aims to find the maximum number of limit cycles bifurcating from a center or a focus. An analogous problem to study the criticality of an isochronous center, this is the maximum number of oscillations of its period function when a perturbation is added to the system. These oscillations are the so-called critical periods. In this talk I will introduce some reversible Darboux linearizable systems of differential equations in the plane, which have allowed us to provide the maximum number of critical periods in a system of fixed degree n so far according to our knowledge.



# Bifurcações de ciclos limites em uma família de campos de vetores suaves por partes

**Luiz Fernando Gonçalves**

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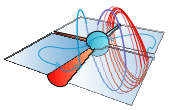
**Resumo:** Faremos o estudo de uma família de campos de vetores suaves por partes no plano com duas zonas apresentando o desdobramento de uma dobra-dobra invisível de costura na origem. Mostramos que dado um inteiro $k$ tal família possui $k$ ciclos limites hiperbólicos de costura numa vizinhança desta singularidade. Além disso, estudamos a relação entre os coeficientes de Lyapunov da família descontínua e de sua regularização.



# T-chains: a chaotic 3D foliation

**Otávio M. L. Gomide**

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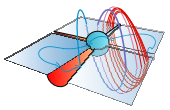
**Abstract:** In this work, we consider a class of $3D$ Filippov systems presenting robust connections between certain typical singularities, known as $T$-singularities. Such systems are locally structurally stable at these singularities and are mainly characterized by the existence of $2D$ invariant cones (named diabolos) with vertices on such points. Our main goal is to discuss the existence of chaotic dynamics when self connections between the cones occur. We highlight that the counterpart of these connections in the smooth case can happen only for highly degenerate systems.
Joint work with M. A. Teixeira.



# Normal forms of constrained differential systems

**Yovani Adolfo Villanueva Herrera**

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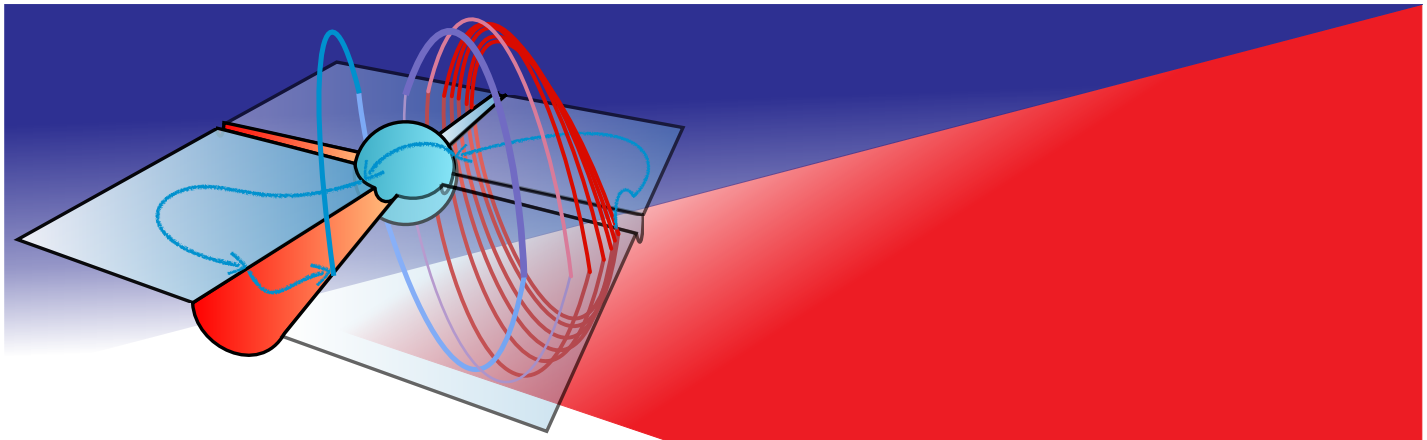
**Abstract:** The subject of this work is the theory of normal forms of smooth vector fields of constrained systems (systems of non-linear differential-algebraic equations). In this study we introduce the qualitative theory of ordinary differential equations, with topics such as stability, structural stability, bifurcations, limit cycles and catastrophes of differential equations, and the functional singularity theory. The goal of this work is classify and normalize constrained systems, first of all from the local point of view, we'll show an idea of the global one and our final objective will be consider this theory to differentiable manifolds of dimension $n \geq 2$.



# X WORKSHOP
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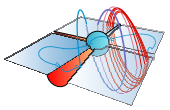
# 2019

## Posters



# Compact leaves of one dimensional principal foliations associated to a plane field in three dimension

**Gomes, Alacyr J.**

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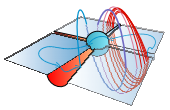
**Abstract:** In this work we will consider a plane distribution $\Delta\eta$ defined by a regular vectors field $\eta : \mathbb{R}^3 \longrightarrow \mathbb{R}^3$. The principal lines associated to $\Delta\eta$ are the integral curves defined by the implicit differential equation

$$2[D\eta(dr), dr, \eta] + \langle \mathrm{rot}(\eta), \eta\rangle \cdot \langle dr, dr\rangle = 0, \quad \langle \eta, dr\rangle = 0,$$

which was established by Y. Aminov (2000).
It will be shown that generically the compact leaves of these foliations are hyperbolic, making use of results from geometric control theory.
In the case where $\Delta\eta$ is integrable these foliations are exactly the principal curvature lines of a one parameter family of surfaces in $\mathbb{R}^3$, a classical subject of differential geometry of surfaces and was introduced by G. Monge (1796). The qualitative theory and global aspects of principal lines were initiated by C. Gutierrez and J. Sotomayor (1982).



# Dinâmica de partículas autopropelidas em fluxos

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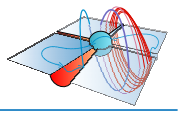
**Resumo:** Estudamos um modelo de partículas autopropelidas em um fluxo bidimensional estacionário correspondente a células convectivas com barreiras de transporte. Essas partículas têm forma de esferoide prolato e sua orientação satisfaz as equações de Jeffery. Consideramos que as partículas têm uma velocidade de autopropulsão diferente de zero quando sua orientação está próxima a uma direção predeterminada. Obtemos um mapa Poincaré sobre o plano de discontinuidade do campo de velocidades e apresentamos os resultados obtidos. Utilizamos métodos numéricos e analíticos para abordar os objetivos.



# Estabilidade estrutural em campos de vetores suaves por partes definidos na esfera $\mathbb{S}^2$

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**Resumo:** Neste trabalho exibimos uma classificação do conjunto dos campos de vetores suaves por partes definidos na esfera $\mathbb{S}^2 \subset \mathbb{R}^3$, que tem o equador $\Sigma = \{(x, y, z) \in \mathbb{S}^2; z = 0\}$ como região de descontinuidade, que são estruturalmente estáveis.
Mais precisamente, consideramos $\mathbb{S}^2 \subset \mathbb{R}^3$, $F : \mathbb{S}^2 \to \mathbb{R}$ tal que $F(x, y, z) = z$, $\Sigma^+ = F^{-1}(0, \infty)$ e $\Sigma^- = F^{-1}(-\infty, 0)$. Sejam $\chi^r = \chi^r(\mathbb{S}^2)$ o espaço dos campos vetoriais de classe $C^r$, $r \geq 1$, definidos em $\mathbb{S}^2$ e, seguindo a convenção de Filippov, considere $\Omega^r = \Omega^r(\mathbb{S}^2, F)$ o espaço dos campos vetoriais $Z$ em $\mathbb{S}^2$ definidos por:

$$Z(\mathrm{x}) = \begin{cases} X(\mathrm{x}), F(\mathrm{x}) \geq 0, \\ Y(\mathrm{x}), F(\mathrm{x}) \leq 0 \end{cases} \quad \text{onde } X,\ Y\ \in \chi^r.$$

Considere $\Sigma_0^{S^2} \subset \Omega(\mathbb{S}^2, F)$, definido da seguinte forma:

$$\Sigma_0^{S^2} = \left\{ \begin{array}{l} Z = (X, Y) \in \Omega(\mathbb{S}^2, F) \text{ tal que,} \\ \text{(a) Todos os equilíbrios de } Z \text{ são hiperbólicos e não estão em } \Sigma; \\ \text{(b) Todas as órbitas periódicas são hiperbólicas e não tocam } \Sigma; \\ \text{(c) Todas as } \Sigma-\text{singularidades são elementares;} \\ \text{(d) Todas as poli-trajetórias fechadas de } Z \text{ são elementares;} \\ \text{(e) } Z \text{ não possui conexão de separatrizes nem conexões de tangências.} \end{array} \right\}$$

**Teorema.** $Z \in \Omega(\mathbb{S}^2, F)$ é estruturalmente estável se, e somente se, $Z \in \Sigma_0^{S^2}$. Além disso, $\Sigma_0^{S^2}$ é aberto.
Nosso próximo objetivo é caracterizar o conjunto do campos de codimensão um em $\Omega(\mathbb{S}^2, F)$.
Este é um trabalho em colaboração com Claudio Aguinaldo Buzzi (IBILCE/UNESP).
Este trabalho é financiado pela FAPESP. Número do processo 2017/08779-8.

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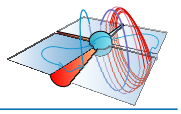

# Dinâmica global de certos sistemas lineares descontínuos no plano separados pela união de duas semirretas

**Ana Maria Alves da Silva**

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**Resumo:** Nos últimos anos houve um interesse considerável no estudo dos sistemas lineares por partes. Existe um interesse especial em estudar a existência, o número e a distribuição dos ciclos limites em sistemas lineares por partes do plano. Em [1] os autores demonstram a não existência de ciclos limites para sistemas lineares contínuos com centros no plano com duas zonas e com três zonas. Os autores demonstram também que para sistemas lineares descontínuos com centros no plano com duas zonas não há ciclos limite mas para o caso de 3 zonas há e a cota é realizável, além disso, os autores propõem uma forma normal para sistemas lineares com centros.

Consideremos os seguintes campos:

$$X(x,y) = \left(-bx - \frac{4b^2+w^2}{4a}y + d,\ ax + by + c\right)\ a > 0,\ w > 0$$

$$Y(x,y) = \left(-Bx - \frac{4B^2+W^2}{4A}y + D,\ Ax + By + C\right)\ A > 0,\ W > 0.$$

Os campos $X$ e $Y$ têm centros lineares tomados a partir da forma normal proposta em [1]. Tome $f : \mathbb{R}^2 \to \mathbb{R}^2$ dada por $f(x,y) = y - |x|$ e defina $X^+ = X_{|_{\Sigma^+}}$ e $X^- = Y_{|_{\Sigma^-}}$ onde $\Sigma = f^{-1}(0)$, $\Sigma^+ = \{(x,y) \in \mathbb{R}^2; f(x,y) \geq 0\}$ e $\Sigma^- = \{(x,y) \in \mathbb{R}^2; f(x,y) \leq 0\}$. Defina agora o seguinte sistema linear suave por partes no plano:

$$Z(x,y) = \begin{cases} X^+(x,y), (x,y) \in \Sigma^+ \\ X^-(x,y), (x,y) \in \Sigma^- \end{cases}. \tag{1}$$

Em nosso trabalho, estamos interessados em estudar a dinâmica (tangências; regiões de deslize, escape, costura, etc.) e a existência de ciclos limites para o sistema definido em (1).

Este é um trabalho em colaboração com Rodrigo Donizete Euzébio (IME/UFG).

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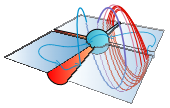

# Integrability of quadratic systems with invariant hyperbolas

**Ana Maria Travaglini**

*Instituto de Ciências Matemáticas e de Computação - Universidade de São Paulo*

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**Abstract:** The goal of this work is to present the investigation in development about integrability of planar quadratic differential systems in the whole class of non-degenerate planar quadratic differential systems possessing at least one invariant hyperbola (QSH). Such class was investigated in [1] where the authors classify it according to its geometric properties encoded in the configurations of invariant hyperbolas and invariant straight lines which these systems possess. In this poster we shall present results about Darboux and Liouvillian integrability of such systems and investigated geometric properties of them.

## References

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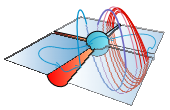

# Conjugations of piecewise vector fields and shift spaces

**Andre do Amaral Antunes**

*Instituto de Biociências, Letras e Ciências Exatas - Universidade Estadual Paulista*

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**Abstract:** Chaos in Piecewise Vector Fields (PSVF, for short) was already discussed in some papers (see [1], [2]). In this work, we will construct a conjugation between some PSVF and two sided shift spaces with any amount of symbols.
The main idea behind this construction is to divide the invariant set where the dynamics is chaotic into compartments and then assign to each compartment one symbol of our shift space. This yields a function of any possible orbit of the vector field to the shift space.
From this relation, we want to translate properties of shift spaces (e.g. entropy), to PSVF, meaning that, for example, one could answer the question of whether one system is "more"chaotic than another.
Joint work with Tiago de Carvalho (USP - Ribeirão Preto).
This work is funded by FAPESP (Process number 2017/18255-6).

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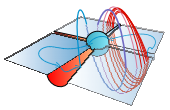

# Symbolic dynamics of piecewise contractions

**Benito Pires**

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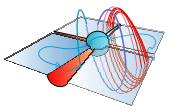
**Abstract:** A map $f : [0,1] \to [0,1]$ is a *piecewise contraction* if locally $f$ contracts distance, i.e., if there exist $0 < \lambda < 1$ and a partition of $[0,1]$ into intervals $I_1, I_2, \ldots, I_n$ such that $|f(x) - f(y)| \leq \lambda |x - y|$ for all $x, y \in I_i$ $(1 \leq i \leq n)$. Piecewise contractions describe the dynamics of many systems such as traffic control systems, queueing systems, outer billiards and Cherry flows. Here I am interested in the symbolic dynamics of such maps. More precisely, we say that an infinite word $i_0 i_1 i_2 \ldots$ over the alphabet $\mathcal{A} = \{1, 2, \ldots, n\}$ is the *natural coding* of $x \in [0,1]$ if $f^k(x) \in I_{i_k}$ for all $k \geq 0$. The aim of this talk is to provide a complete classification of the words that appear as natural codings of injective piecewise contractions.



# Inflection points on hyperbolic tori of $\mathbb{S}^3$

**B. Freitas**

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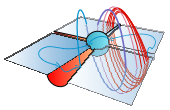
**Abstract:** Families of hyperbolic tori in $\mathbb{S}^3$ (the asymptotic lines are globally defined) without double inflection points is provided. More precisely, a small deformation of the Clifford torus parametrized by asymptotic lines is analyzed and it is described by the set of inflections of the two families of asymptotic lines $\mathcal{A}_1$ and $\mathcal{A}_2$. Denote by $\mathcal{I}_i$ the set of inflections of the asymptotic lines of the associated asymptotic foliation $\mathcal{A}_i$, also called flecnodal set. The intersection $\mathcal{I}_1 \cap \mathcal{I}_2$ is called the set of double inflections. It is shown that by an appropriated deformation of the Clifford torus the set $\mathcal{I}_1 \cap \mathcal{I}_2$ is empty for the deformed surface. This gives a negative answer to a problem formulated by S. Tabachnikov and V. Ovskienko [Hyperbolic Carathéodory Conjecture, Proc. of the Steklo Inst. of Math. **258** (2007), p. 178-193] in the context of spherical surfaces.
Joint work with R. Garcia (IME/UFG).



# Direction transition matrix

**Cícero Rumão G. de Sousa Jr.**

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**Abstract:** We present a transition matrix given by the directional transition matrix that covers the flow defined Conley isomorphism. We will show some examples and a computational application using Mathematica software.
The directional transition matrix was developed in [3] and [4], the advantage of this more general approach is that it allows us to detect larger families of bifurcation orbits in continuation than those that are detected by the singular and topological transition matrices.
The work will be based in [1] and [2].

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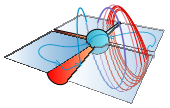

# High order Melnikov analysis in nonsmooth differential systems with nonlinear switching manifold

**Dayane R. Cruz**

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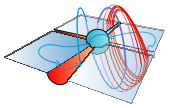
**Abstract:** The Averaging Theory states that periodic solutions of a perturbed system bifurcating a continuum of periodic solutions can be detected by the "Averaged" functions of the system. This holds for continuous systems, however it was noticed that the same does not occur for discontinuous systems. In "Melnikov analysis in nonsmooth differential systems with nonlinear switching manifold" article written by Dr. Jéfferson L. R. Bastos, Dr. Claudio Buzzi, Dr. Jaume Llibre, and Dr. Douglas D. Novaes, it was demonstrated that the functions of bifurcation, also called of Melnikov's functions, which control the birfurcation of periodic solutions differ from the "averaged" ones by an increment that depends on the "discontinuity jump" and the geometry of the switching manifold. The purpose of this work is to generalize the previous study for higher order perturbations.



# Conley Index Theory for trajectories periodic with sliding region

**Ewerton Rocha Vieira**

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**Abstract:** We present results of Conley Index Theory that guarantee existence of periodic trajectories with sliding region, see [1, 2, 3, 4].

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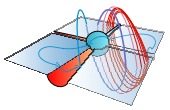

# Inseparable leaves in the plane

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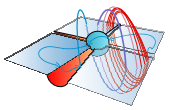
**Abstract:** We provide a new lower bound for the maximum number of inseparable leaves a chordal system in the plane of degree $n$ can have by using the blow-up technique in a different way.



# Regularization of Filippov systems near regular-tangential singularities and tangential polycycles

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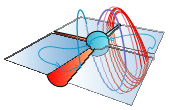
**Abstract:** Understanding how tangential singularities evolves under regularization processes was one of the first problem concerning regularization of Filippov systems. Indeed, in the earlier work of Sotomayor and Teixeira, it is proved that around a regular-fold singularity of a Filippov system Z, the regularized system Z possesses no singularities. Recently, some works got deeper results by studying the corresponding slow-fast problems. In some articles asymptotic methods were used to study Cn-regularizations of generic regular-fold singularities and fold-fold singularities, respectively. In other articles, the Blow-up method was adapted to study Cn-regularizations of fold-fold singularities and an analytic regularization of a regular-fold singularity, respectively. In this work, we are interested in Cn-regularizations of regular-tangential singularities through blow-up methods. Our main result extend for degenerate regular-tangential singularities the results obtained for regular-fold singularities. The main diference between our problem and the problem addressed in the other works is that a regular-fold singularity admits a normal form which simplify a lot the study. Here, we have to deal with higher order terms. We are also interested in Cn-regularizations of Filippov systems containing regular-tangential polycycles.



# A framework to study piecewise smooth dynamical systems in the presence of a singular switching manifold

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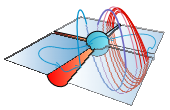
**Abstract:** The theory of piecewise smooth dynamical systems, in particular, Filippov systems, provides a natural framework for modeling various phenomena in the nature and has had a fast development in the last decades. However, most of the studies in this area are directed to Filippov systems with regular switching manifolds, where the Filippov dynamics is well defined. In this work, we study a 3D cross-like singular configuration of the switching manifold, where the Filippov dynamics ins't well defined. More precisely, we propose a framework that, through blow-ups and slow-fast theory, extends Filippov dynamics to this singular configuration (and possibly others). This framework has been applied to the piecewise linear case and, until now, we have successfully unfolded the dynamics of the constant subcase. A complete unfold of the general linear case is expected in a near future. Joint work with Ricardo Miranda Martins.



# Rational first integrals of the Lienard equations: the solution to the Poincaré problem for the Lienard equation

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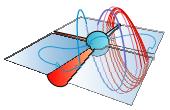
**Abstract:** Poincaré in 1891 asked about the necessary and sufficient conditions in order to characterize when a polynomial differential system in the plane has a rational first integral. Here we solve this question for the class of Liénard differential equations $\ddot{x} + f(x)\dot{x} + x = 0$, being $f(x)$ a polynomial of arbitrary degree. As far as we know it is the first time that all rational first integrals of a relevant class of polynomial differential equations of arbitrary degree has been classified.
Joint work with Jaume Llibre (UAB) and Claudio Pessoa (IBILICE/UNESP).



# Fibrations and global injectivity of local homeomorphisms

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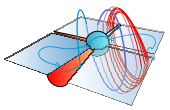
**Abstract:** Given $X$ a path connected space and $g\colon X \to \mathbb{R}$ a local fibration on its image, we prove that $g$ satisfies a kind of deformation and consequently we obtain the path connectedness of its level sets. Then we provide global injectivity and invertibility theorems for local homeomorphisms $f\colon X \to \mathbb{R}^n$. These generalize known analytical results such as those given by Balreira and by Silva and Teixeira.



# Uma condição suficiente para recorrência na T-singularidade

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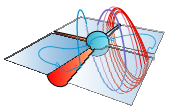
**Resumo:** Neste trabalho apresentamos algumas condições suficientes sobre a forma normal do campo e da aplicação do primeiro retorno na vizinhança da T-singularidade.



# Sobre conjuntos limite para uma classe de sistemas de Filippov possuindo movimento deslizante

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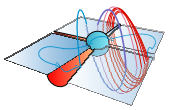
**Resumo:** Neste trabalho, a estrutura global de trajetórias de uma classe sistemas de Filippov no plano, que são confinadas em um compacto são estudadas. É assumido que o sistema de Filippov é definido por dois campos de vetores $C^r$ cujas trajetórias são separadas por uma curva suave $\Sigma$, cada um possuindo no máximo um ponto de tangência com $\Sigma$. O comportamento das trajetórias globais é completamente analizado e seus conjuntos limite são classificados. Além disso, as trajetórias podem comutar com $\Sigma$ infinitas vezes, inclusive visitando as regiões de deslise ou escape. Consequentemente, apresentamos uma versão do aclamado Teorema de Poincaré-Bendixson sem evitar movimento deslizante. Nesta direção alguns conjuntos (limite) apresentando movimento deslizante ou mesmo interior não-vazio são obtidos. No último caso, provamos a existência de caos não determinístico. Algumas características importantes das trajetórias são distinguidas analizando condições simples em termos dos pontos de tangência, como condições suficientes para a existência de ciclos limite deslizantes. Finalmente, exemplos de classes importantes de sistemas de Filippov que se ajustam as nossas hipóteses, como os lineares por partes, são apresentados, e vemos que pode ocorrer caos mesmo neste caso.



# Crossing limit cycles for a class of piecewise linear differential centers separated by a conic

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**Abstract:** These last years the study of the version of Hilbert's 16th problem for piecewise linear differential systems in the plane, has increased strongly and there are many papers studying the maximum number of crossing limit cycles when the differential system is defined in two zones separated by a straight line, in particular in [1, 2] it was proved that piecewise linear differential centers separated by a straight line have no crossing limit cycles, but in the papers [3, 4] it was shown that the maximum number of crossing limit cycles of piecewise linear differential centers, can change depending of the shape of the discontinuity curve. In this work we study the maximum number of crossing limit cycles of piecewise linear differential centers separated by a conic.
Joint work with J. Jimenez (IME/UFG) and J. Llibre (UAB).

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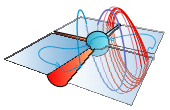

# Existence of $C^k$-invariant foliations for Lorenz-type maps

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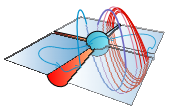
**Abstract:** In this poster, under conditions similar to those in Shashkov and Shil'nikov (1994) we show that a $C^{k+1}$ Lorenz-type map $T$ has a $C^k$ codimension one foliation which is invariant under the action of $T$.



# Topological transitivity of Filippov systems

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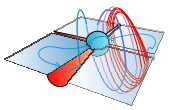
**Abstract:** We deal with Filippov systems defined on a 2-dimensional manifold. We analyse the concept of topological transitivity for these systems. We obtain similar results for the context of uniqueness of flows, but once sliding or escaping regions are present we are able to say much more things. Transitivity in this case is much more related to chaos (devaney's sense).
Joint work with R. Euzébio.



# Shilnikov connections arising from boundary equilibrium bifurcations

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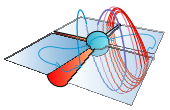
**Abstract:** Generally speaking, a Shilnikov connection is a homoclinic connection through a hyperbolic saddle-focus equilibrium. In the nonsmooth context, it is possible to obtain a Shilnikov like connection through a pseudo saddle-focus equilibrium in the sliding region. In this work, we provide some models of nonsmooth systems presenting Shilnikov connections arising from boundary equilibrium bifurcations. Joint work with D. D. Novaes (UNICAMP).



# Hybrid bifurcation of limit cycles in quadratic piecewise system

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**Abstract:** Consider the piecewise polynomial vector field

$$Z^{\pm} = \begin{cases} \dot{x} = -b^{\pm}y \pm a^{\pm}x \pm (b^{\pm})^2y^2 \mp \left(4/3(a^{\pm})^2 + 1/3(b^{\pm})^2 + 2\right)x^2, \\ \dot{y} = b^{\pm}x \pm a^{\pm}y - a^{\pm}b^{\pm}y^2 \mp \left((a^{\pm})^2 + (b^{\pm})^2 + 1\right)xy + \\ \quad + \left(\left(5(a^{\pm})^2 - 10(b^{\pm})^2 + 9\right)a^{\pm}\right)x^2/(15b^{\pm}), \end{cases} \quad \text{if } (x,y) \in \Sigma^{\pm},$$

with $\Sigma^{\pm} = \{(x,y) : \pm h(x,y) > 0\}$, where $h(x,y) = y - \tan(\epsilon)x$. System (1) has two weak foci of order three in $(0, \pm 1/b^{\pm})$ and a focus at the origin. We study the number of periodic orbits that bifurcate from the three foci using the Lyapunov constants theory. This normal form is an adaptation of the result in [1] for piecewise systems. For this extension, we find a point in the parameter space corresponding to a hybrid configuration of limit cycles $(3, 5, 3)$.
Joint work with Alex C. Rezende and Joan Torregrosa.

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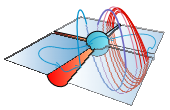

# Análise qualitativa local do sistema de Rossler

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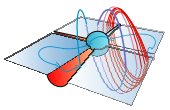
**Resumo:** Neste trabalho serão apresentados estudos matemáticos de caráter qualitativo e numérico do sistema de Rossler, os quais se remetem a descrever a dinâmica do sistema em inúmeros aspectos. Será feita uma abordagem analítica do sistema, isto por intermédio de resultados clássicos da teoria qualitativa de sistemas dinâmicos, em destaque o teorema de Grobman-Hartman, seguido também de uma análise numérica do sistema, a qual se remete a estudar, sob determinadas condições, pontos críticos do sistema e a sua linearização. Por fim serão considerados alguns problemas práticos em que o sistema pode ser empregado.
Este é um trabalho em colaboração com Caio Augusto Santos Magalhães (IME/UFG).



# Bifurcação de ciclos limites a partir de centros em variedades centrais de campos de vetores em $\mathbb{R}^3$

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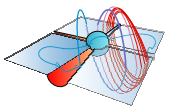
**Resumo:** Neste trabalho, apresentamos um método de estimação da ciclicidade para sistemas tridimensionais que têm um centro na origem sobre a variedade central. Mais precisamente, consideramos perturbações do sistema

$$\begin{cases} \dot{u} = -v + P(u, v, w), \\ \dot{v} = u + Q(u, v, w), \\ \dot{w} = -\mu w + R(u, v, w), \end{cases}$$

que mantém a singularidade na origem e a propriedade que os autovalores da parte linear do campo vetorial correspondente sejam dois imaginários puros e um real não nulo.

Para os sistemas considerados, podemos definir os coeficientes focais $g_{kk0}$ e os coeficientes de Lyapunov $L_k$ que dependem dos parâmetros de perturbação $\lambda \in \Lambda \subset \mathbb{R}^n$. Estes coeficientes caracterizam a *variedade de Bautin*, o conjunto dos parâmetros para os quais o sistema tem um centro na origem sobre a variedade central. Enunciamos o teorema que exibe a conexão entre a independência das partes lineares dos coeficientes (tanto os de Lyapunov como os focais) e o número de ciclos limites de pequena amplitude que bifurcam a partir de um ponto da variedade de Bautin. Exemplificamos, aplicando o teorema para o sistema de Moon-Rand.

Este é um trabalho em colaboração com Claudio Gomes Pessoa (IBILCE/UNESP).



# Global phase portraits of the quadratic polynomial Liénard differential systems

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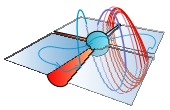
**Abstract:** The quadratic polynomial differential systems and their applications have been studied intensively these last thirty years. In particular, the polynomial Liénard differential systems and their applications also have been analyzed by many authors these recent years. Up to now the phase portraits in the Poincaré disc of the quadratic polynomial Liénard differential systems have not been studied, their study is the goal of this work. More precisely, we classify the different topological phase portraits in the Poincaré disc of the systems

$$\dot{x} = y, \qquad \dot{y} = (ax + b)y + cx^2 + dx + e,$$

where $(x, y) \in \mathbb{R}^2$ are the variables and $a, b, c, d, e$ are real parameters.
Joint work with M. Gouveia (IBILCE-UNESP) and J. Llibre (UAB-Barcelona).



# Critical curves for the total normal curvature on surfaces

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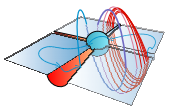
**Abstract:** Examples of curves derived from the calculation of variations in geometry have been extensively studied. Some curves initially defined with geometric properties can be characterized as a solution of variational problems. A known example of such curves is the geodetic curve.
Our aim in this work is to find the curves for which the total normal curvature

$$K_n = \int_p^q k_n ds,$$

is an extremal and to study the dynamical and geometric properties of those curves.



# On the formation of nested invariant tori and hidden chaotic attractor in the Sprott A system

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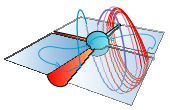
**Abstract:** We consider the well-known Sprott A system, which is a particular case of the Nosé-Hoover oscillator, related to problems of molecular dynamics. It is a three-dimensional quadratic differential system depending on a real parameter $a$ and, for $a = 1$, was shown to present a hidden chaotic attractor. In this work, we study the creation of this chaotic attractor, performing a bifurcation analysis by varying the parameter $a$. More specifically, we prove that, for $a = 0$, the Sprott A system has a line of equilibria in the $z$–axis, the phase space is foliated by concentric invariant spheres with two equilibrium points located at the south and north poles and each one of these spheres is filled by heteroclinic orbits of south pole–north pole type. For $a \neq 0$, the spheres are no longer invariant algebraic surfaces and the heteroclinic orbits are destroyed. We do a detailed numerical study for $a > 0$ small, showing that small nested invariant tori and a *limit set*, which encompasses these tori and is the $\alpha$– and $\omega$–limit set of almost all orbits in the phase space, are formed in a neighborhood of the origin. As the parameter $a$ increases, this *limit set* evolves into a hidden chaotic attractor, which coexists with the nested invariant tori. In particular, we find hidden chaotic attractors even for $a < 1$. Furthermore, we make a global analysis of Sprott A system, including the dynamics at infinity via the Poincaré compactification, showing that for $a > 0$ the only orbit which escapes to infinity is the one contained in the $z$–axis, all other orbits are either homoclinic to a limit set (or to a hidden chaotic attractor, depending on the value of $a$) or are contained on an invariant torus, depending on the initial condition considered.
Joint work with Alisson C. Reinol (Universidade Estadual de Maringá).

**Keywords:** *Sprott A system, hidden chaotic atractor, invariant algebraic surfaces, nested invariant tori, homoclinic and heteroclinic orbits.*



# A new chaotic bridge system

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**Abstract:** We present a study of dynamic aspects of the autonomous system

$$\dot{x} = yz, \quad \dot{y} = x - y, \quad \dot{z} = 1 - x(\alpha y + \beta x),$$

where $(x, y, z) \in \mathbb{R}^3$ and $\alpha, \beta \in [0, 1]$ are two parameters. It contains the so called Sprott B and the Sprott C systems (see [1]) at the two extremes of its parameter spectrum and we called it Sprott BC system. Such system can be considered as a *bridge system* which unify Sprott B and Sprott C systems (see [3] and [6], for instance). Here we present the complete description of its singularities and according to [5] we show that this system passes through a Hopf bifurcation at $\alpha = 0$ and we compute the respective first Lyapunov coefficient. Using Poincaré compactification of a polynomial vector field in $\mathbb{R}^3$ (see Appendix A of [2] for more details) we give a complete description of its dynamic on the Poincaré sphere at infinity. Finally we state some results about the non integrability of Sprott BC system.
Joint work with Regilene Oliveira (ICMC/USP).

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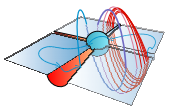

# Existence of invariant sets in piecewise linear vector fields in $\mathbb{R}^3$ with sliding region

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**Abstract:** The objective consists of the exploration of the linear vector fields in $\mathbb{R}^3$, $X(t, x)$, separated by a plane (discontinuity surface) and we assume the existence of two parallel lines where the degree of contact of the fields is two (see [2]). In this context, together with the Filippov's convention (see [1]), it allows us first to make the qualitative study of the sliding vector field associated with $X$, $X^s$, and thus reach our main goal, which is to determine the existence of invariant sets, such as cylinders and periodic orbits and to determine the global dynamics of the vector field $X(t, x)$.
Joint work with Durval José Tonon (IME/UFG).

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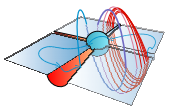

# Dinâmica global para uma classe de sistemas de Filippov

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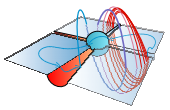
**Resumo:** Consideraremos uma classe de sistemas suaves por partes cujas soluções estão associadas às chamadas soluções do tipo "peakon" e "multipeakon" para um sistema de equações parciais. Para essa classe de sistemas nosso objetivo é estudar o comportamento global e assintótico de suas soluções.



# Campos de vetores suaves por partes bidimensionais onde não vale a convenção de Filippov

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**Resumo:** Apresentaremos uma possível classificação dos campos de vetores suaves por partes bidimensionais onde não vale a convenção de Filippov que são de codimensão 0 e 1, possuindo a cruz como descontinuidade, com o objetivo de determinar uma forma normal para cada caso, conforme foi feito nos trabalhos [1], [2], [3], [4], onde vale a convenção de Filippov.

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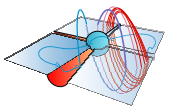

# Estimadores de elemento de arco e de curvatura projetiva para curvas planas

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**Resumo:** Neste trabalho iremos estudar estimadores de elementos de arcos e de curvatura projetiva para curvas planas, quando as curvas são representadas por pontos e direções tangentes. A motivação para o estudo da geometria projetiva veio das belas artes. Foi em 1425 que o arquiteto italiano Brunelleschi começou a discutir a teoria geométrica da perspectiva, que foi consolidada em um tratado por Alberti alguns anos depois [2].
A geometria projetiva plana pode ser descrita como o estudo de propriedades geométricas que não são alteradas pela "projeção central", ou seja, permanecem invariantes sob todas as transformações projetivas do espaço no qual se encontra. Alguns exemplos de invariantes projetivos são a retidão das linhas, a relação de posição de pontos e retas, e a razão cruzada de quatro pontos em uma reta, ou feixe de 4 retas passando por um ponto [1] e [4].
Uma curva regular plana projetiva $A(\sigma)$ parametrizada pelo elemento de arco projetivo $\sigma$ satisfaz uma equação diferencial linear de terceira ordem

$$\frac{d^3A}{d\sigma^3} + 2k(\sigma)\frac{dA}{d\sigma} + (1 + k'(\sigma))A = 0. \tag{1}$$

A função $k(\sigma)$ definida pela equação (1) será chamada de *curvatura projetiva.*
Para um gráfico $\gamma(t) = (t, h(t), 1)$ numa carta afim $(x, y, 1)$ temos a equação diferencial linear de terceira ordem

$$\gamma''' - \frac{h'''}{h''}\gamma'' = 0.$$

Definindo $-\frac{h'''}{h''} = \frac{3}{2}\frac{\xi'}{\xi}$, temos que o elemento de arco projetivo é $H = \frac{1}{4}\frac{\xi'''}{\xi}$.
A curvatura projetiva é dada por

$$k = \frac{\sqrt[3]{2}}{36}\,\frac{\left(28\,\xi''''^2\xi^2 - 8\,\xi''''\ \xi'''\,\xi'\,\xi + 7\,\xi'^2\xi'''^2 - 30\,\xi\xi''\,\xi'''^2\right)}{\xi^{\frac{4}{3}}\xi'''^{\frac{8}{3}}}.$$

Observamos que $H = 0$ (elemento de arco projetivo) para as cônicas e portanto a sua curvatura projetiva não está definida. Veja [3] e [4].
Na forma normalizada de (1) uma curva $A(\sigma)$ de curvatura projetiva zero satisfaz a equação diferencial $A'''(\sigma) + A(\sigma) = 0$. Uma solução particular dessa equação diferencial é a espiral logarítmica.

Nesse trabalho iremos fazer uma abordagem dos trabalhos de Thomas Lewiner e Marcos Craizer [5, 6], apresentando o elemento de arco e curvatura baseados em *splines* projetivos, construídos por meio da adequação de espirais logarítmicas às amostras pontuais tangentes.

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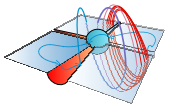

# Gradient systems of harmonic polynomials

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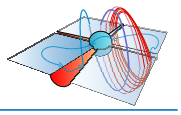
**Abstract:** We characterize all local phase-portraits of the finite and infinite singular points of the gradient systems defined by the real harmonic polynomials in two variables.
We classify all the non-equivalent topological phase portraits of the gradient systems in the Poincaré disc defined by harmonic polynomials of degree less than five.



# Sobre sistemas com impasse e o estudo de fluxos em superfícies invariantes

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**Resumo:** Sistemas com impasse são conhecidos na literatura por generalizar sistemas de equações diferenciais ordinárias (EDO's), além de modelar diversos problemas físicos, principalmente em engenharia elétrica. Mais precisamente, um sistema com impasse é escrito na forma

$$A(x)\dot{x} = F(x),$$

onde $x \in \mathbb{R}^n$, $A(x)$ é uma matriz $n \times n$ e $F : \mathbb{R}^n \to \mathbb{R}^n$ é uma aplicação diferenciável. Este tipo de sistema é usado para estudar a dinâmica sobre a variedade lenta de um problema de perturbação singular. Neste trabalho, vamos usar esta classe de sistemas para estudar o fluxo de sistemas suaves em superfícies invariantes. Em particular, vamos estudar o fluxo de sistemas suaves sobre superfícies da forma

$$M = \{(x, y, z) \in \mathbb{R}^3 | f(x, y)z - g(x, y) = 0\},$$

onde $f, g : \mathbb{R}^2 \to \mathbb{R}$ são aplicações suaves. Superfícies da forma $M$ podem ser conexas, desconexas, suaves, singulares, etc. Além disso, alguns sistemas famosos na literatura (Equação de Falkner-Skan, Sistema de Lorenz, Sistema de Chen) admitem superfícies dessa forma como superfícies invariantes, e é justamente nesses exemplos que aplicaremos os resultados obtidos.
Este é um trabalho em colaboração com Paulo Ricardo da Silva (IBILCE/UNESP).
Este trabalho é financiado pela FAPESP (processo 2016/22310-0).

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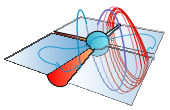

# The fundamental symmetry of homogeneous binary differential equations

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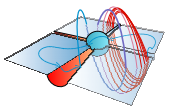
**Abstract:** Homogeneous binary differential equations are implicit differential equations of the form $a(x,y)dy^2 + 2b(x,y)dxdy + c(x,y)dx^2 = 0$, where the coefficients $a, b, c$ are polynomial functions of degree $n$. This special class of binary differential equations has the property that the symmetry group is always no trivial. The existence of a fundamental symmetry in the group allow us to know when the two foliations have distinct shapes or not. Moreover, we can see that the invariant straight lines that can occur on the configurations have different behavior depending on parity of the degree of the coefficients.
Joint work with M. Manoel.



# Os teoremas da Variedade Estável e de Grobman-Hartman

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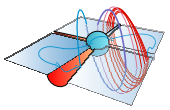
**Resumo:** O objetivo deste pôster é apresentar dois importantes resultados da Teoria Qualitivativa das Equações Diferenciais Ordinárias: O Teorema da Variedade Estável e o Teorema de Grobman-Hartman.



# Boundary equilibrium bifurcations in a DC-DC buck power converter feeding a load of CPL-type

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**Abstract:** In typical dc distribution systems with a cascaded converter architecture, loads connected to the bus by an electronic converter behave as constant power drawn from the feeder, and can be modelled as a constant power load (CPL); see [10]. This work considers a 3D-Filippov system that models the voltage control process at the output of the dc-dc bidirectional buck converter by feeding a CPL.
The so-called *Boundary Equilibrium Bifurcations* (BEBs) are characterized by the collision of a regular equilibrium point of system with its discontinuity manifold; see [3]. Such BEBs are unique bifurcations of piecewise-smooth dynamical systems and, in recent years, have motivated several studies of their unfoldings (see [5, 6, 7, 8]), which was started by Filippov [4]. However, most of the works have considered two-dimensional systems and there are few studies related to BEBs in three-dimensional systems; see [2, 9].
The goal of this work is to present some of the results on the BEBs in $\mathbb{R}^3$ obtained in [1] [Chapter 7, Section 7.7] from an applied study performed with interconnected power converters and under a sliding mode control strategy. These results provide the conditions on the system parameters for the occurrence of BEBs, for the *persistence* and *nonsmooth fold* cases. In addition, from numerical simulations are observed a *boundary focus bifurcation* and the birth of a limit cycle with a sliding orbit segment. Other bifurcations of equilibria (saddle-node, Hopf and sliding Hopf) are also discussed in this work.

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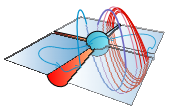

# Aplicação de campos de vetores suaves por partes na modelagem de câncer e HIV

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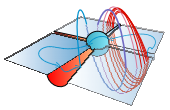
**Resumo:** Iremos estudar alguns modelos de evolução de células cancerosas e também de evolução do virus HIV utilizando campos vetoriais suaves por partes. Destaca-se a ocorrências de singularidades típicas, tais como dobra-dobra e cúspide-dobra.



# Existência de centros em sistemas diferencias planares simétricos

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**Resumo:** Investigamos condições para garantir a existência de centros em sistemas diferenciais planares cúbicos possuindo diferentes tipos de simetrias. Primeiramente encontramos as formas normais para tais sistemas usando quatro tipos diferentes de simetrias.
Em seguida, exibimos as condições necessárias e suficientes para a existência simultânea de dois centros para tais sistemas e também as condições necessárias e suficientes para a isocronicidade de tais centros.
Este é um trabalho em conjunto com Maša Dukarić (CAMTP, Maribor, Eslovênia) e Regilene Oliveira (ICMC-USP, São Carlos, Brasil).