TYAN THEMATIC WORKSHOP IN MATHEMATICS AND ADVANCED SCHOOL IN MATHEMATICS

November 7-11, 2022
IME-USP

INVITED SPEAKERS

ALEXANDER ARBIETO – TYAN MEMBER, UNIVERSIDADE FEDERAL DO RIO DE JANEIRO, BRAZIL
DANIEL PELLEGRINO – TYAN MEMBER, UNIVERSIDADE FEDERAL DA PARAÍBA, BRAZIL
EDERSON MOREIRA DOS SANTOS – BAS MEMBER, ICMC/UNIVERSIDADE DE SÃO PAULO, BRAZIL
EDUARDO TEIXEIRA – TYAN MEMBER, UNIVERSITY OF CENTRAL FLORIDA, USA
EMÍLIO LAURET – INSTITUTO DE MATEMÁTICA DE BAHÍA BLANCA, ARGENTINA
ERNESTO LUPERCIO – TYAN MEMBER, CENTRO DE INVESTIGACIÓN Y DE ESTUDIOS AVANZADOS DEL IPN, MEXICO
GABRIELA PLANAS – UNIVERSIDADE ESTADUAL DE CAMPINAS, BRAZIL
JAQUELINE MESQUITA – TYAN MEMBER, UNIVERSIDADE DE BRASÍLIA, BRAZIL
KETI TENENBLAT – TWAS MEMBER, UNIVERSIDADE DE BRASÍLIA, BRAZIL
PAULO CORDARO – TWAS MEMBER, IME/UNIVERSIDADE DE SÃO PAULO, BRAZIL
YOSHIKO WAKABAYASHI – BAS MEMBER, IME/UNIVERSIDADE DE SÃO PAULO, BRAZIL

MINI-COURSES

HELENA NUSSENZVEIG LOPES – BAS MEMBER, TWAS AWARD 2022, UNIVERSIDADE FEDERAL DO RIO DE JANEIRO, BRAZIL
MARIEL SAEZ – PONTIFICIA UNIVERSIDAD CATÓLICA DE CHILE
YOSHIHARU KOHAYAKAWA – TWAS MEMBER, IME/UNIVERSIDADE DE SÃO PAULO, BRAZIL

SCIENTIFIC COMMITTEE

ALICIA DICKENSTEIN – UNIVERSIDAD DE BUENOS AIRES, ARGENTINA
CARLOS KENIG – UNIVERSITY OF CHICAGO, USA
MARIA JOSÉ PACÍFICO – UNIVERSIDADE FEDERAL DO RIO DE JANEIRO, BRAZIL
PAOLO PICCIONE – IME/UNIVERSIDADE DE SÃO PAULO, BRAZIL
RENATO ITURRIAGA – CENTRO DE INVESTIGACIÓN EN MATEMÁTICAS, MEXICO

ORGANIZING COMMITTEE

PAOLO PICCIONE – IME/UNIVERSIDADE DE SÃO PAULO, BRAZIL – COORDINATOR
JAQUELINE MESQUITA – UNIVERSIDADE DE BRASÍLIA, BRAZIL
FERRÁN VALDEZ – UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO, MEXICO
EDUARDO TEIXEIRA – UNIVERSITY OF CENTRAL FLORIDA, USA

ORGANIZATION

SBM SOCIEDADE BRASILEIRA DE MATEMÁTICA
TYAN TWAS YOUNG AFFILIATES/ALUMNI NETWORK
Academia Joven de Argentina
TWAS LACREP Latin America and the Caribbean Regional Partner

SUPPORT

105 anos 1916 - 2021 ACADEMIA BRASILEIRA DE CIÊNCIAS
SOCIEDAD MATEMÁTICA MEXICANA

Welcome to

6th TYAN Thematic Workshop in Mathematics and 1st Advanced School in Mathematics

TYAN Thematic Workshop in Mathematics and Advanced School in Mathematics

Book of Abstracts

TYAN Thematic Workshop in Mathematics and Advanced School in Mathematics

Coordinator

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Jaqueline Mesquita (University of Brasília, Brazil)
Paolo Piccione (IME/University of São Paulo, Brazil – Coordinator)

Local Committee

Amanda de Melo Souza (IME/University of São Paulo, Brazil)
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Bruno Mascaro (IME/University of São Paulo, Brazil)
Denis de Assis Pinto Garcia (IME/University of São Paulo, Brazil)
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Isabelle Siqueira da Costa (IME/University of São Paulo, Brazil)
Juan César D' Avila Baumgratz (IME/University of São Paulo, Brazil)
Jucileide dos Santos (University of Brasília, Brazil)
Luana Giacomini Barbosa (IME/University of São Paulo, Brazil)
Pedro Henrique Alves de Queiroz (IME/University of São Paulo, Brazil)

Opening Ceremony: Monday, November 7, from 08:30 to 9:00

Paolo Piccione - Chair of the Organizing Committee
Franco Cabrerizo - Chair of the Executive Committee - TYAN
Helena Nader - President of the BAS
Luiz Davidovich - Secretary-General of TWAS
Virgílio de Almeida - Chair TWAS-LACREP
Sergio Oliva - Director of IME/USP
Jaqueline Mesquita - Member of the Executive Committee TYAN

Invited Speakers

Alexander Arbieto- TYAN Member (Federal University of Rio de Janeiro, Brazil)
Daniel Pellegrino - TYAN Member (Federal University of Paraíba, Brazil)
Ederson Moreira dos Santos - Bas Member (ICMC/ University of São Paulo, Brazil)
Eduardo Teixeira -TYAN Member (University of Central Florida, USA)
Emílio Lauret (Instituto de Matemática de Bahía Blanca, Argentina)
Ernesto Lupercio - TYAN Member(Centro de Investigación Y de Estudios Avanzados Del IPN,Mexico)
Gabriela Planas (Estadual University of Campinas, Brazil)
Helena Nussenzveig Lopes-BAS Member, TWAS Award 2022(Federal University of Rio de Janeiro)
Jaqueline Godoy Mesquita - TYAN Member (University of Brazilia, Brazil)
Keti Tenenblat - TWAS Member (University of Brazilia, Brazil)
Paulo Cordaro - TWAS Member (IME/University of São Paulo, Brazil)
Yoshiko Wakabayashi - BAS Member (IME/University of São Paulo, Brazil)

Mini-Courses

Mariel Saez (Pontificia Universidad Católica de Chile, Chile)
Yoshiharu Kohayakawa - TWAS Member (IME/University of São Paulo, Brazil)

Panel

Panel 1: The actions of Committees of Gender and Diversity

Vanderlan da Silva Bolzani - UNESP, TWAS member (moderator)
Marcia Barbosa - UFRGS, Brazil, Member of Committee of Gender and Diversity of TWAS
Cintya Benedito - Unesp, Member of Committee of Gender and Diversity of SBM/SBMAC
Mariel Saez - PUC/Chile, Member of Colectivo de mujeres matemáticas en Chile
Christina Brech - USP, Member of Committee of Gender and Diversity of UMALCA

Panel 2: 40 years of birthday of Revista do Professor de Matemática

Ana Catarina Hellmeister - member of the editorial board of Revista do Professor de Matemática
Pastore de Mello - member of the editorial board of Revista do Professor de Matemática

Edmilson Luis Motta - Editor-in Chief of Revista do Professor de Matemática
Maria Elisa E. L. Galvão - member of the editorial board of Revista do Professor de Matemática
Renate Watanabe - Honorary member of the editorial board of Revista do Professor de Matemática

Panel 3: "How can mathematics be used to address global challenges?"

Roberto Imbuzeiro - Impa (moderator)
Carlile Lavor - IMECC/Unicamp
José Alberto Culminato - ICMC/USP
Nancy Garcia - IMECC/Unicamp
Paulo Artaxo - IF, USP, TWAS member

Panel 4: "Opportunities for young researchers"

Paolo Piccione - IME/USP (moderator)
FAPESP representative
BAYLAT representative
EURAXESS representative
Heidelberg Laureate Forum representative
Oberwolfach Representative
CNPq representative

Panel 5: TWAS Young Affiliates Network Panel
Eduardo Teixeira - TYAN member, Brazil (moderator)
Federico Brown - TYAN member, Brazil
Jaqueline Mesquita - Member of the Executive Committee of TYAN, Brazil
Leslie Tejeda - TYAN member, Bolivia
Pablo Bolaños - TYAN member, Costa Rica

Posters

- Antonio Ronaldo Gomes Garcia - A discontinuous differential calculus in the framework Colombeau's full algebra
- Aryel Kathleen Araújo Silva - Kurzweil Integral and Generalized ODEs
- Elvis da Silva Rodrigues - TBA
- Emanoel Freire - Hyperbolic Manifolds with a large Kissing number
- Felippe Guimarães - Minimal intrinsically homogeneous submanifolds of hyperbolic space in codimension two
- Gabriela C. Silva- Hausdorff dimension of Julia sets of quadratic functions
- Giovana Melo dos Santos - The constrained Knapsack problem

- Kauê Orlando Pereira - Summary About Varieties of polynomial growth

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Social Activities

Welcome Recepion with musical presentation

The welcome reception will take place on Monday, November 7, from 18:00 to 19:00 with a musical performance by Trio Sonoroso (Instagram: @TrioSonoroso).

Cocktail

The cocktail of the event will be held on Tuesday, November 08, from 18:00 to 19:00

Conference Dinner

- Conference dinner will take place at the restaurant "Bovinu'S Churrascaria Rebouças", on November 10 at 20:00.
- For dinner, it is necessary to inform the organizing committee, if you will participate by November 9.
- The cost of dinner is 110 BRL (R$ 110), drinks and service charge not included.

Event rooms/IME-USP

From monday to tuesday: Auditório Jacy Monteiro, ground floor of Block B.
From wednesday to friday: Imre Simon, Bloco C.

Event address

University of São Paulo
Institute of Mathematics and Statistics (IME)
University of São Paulo campus Butantã
05508-090 São Paulo - SP

TYAN Thematic Workshop in Mathematics and Advanced School in Mathematics

Online Activities

Links

Day 01

Link Zoom:
https://us02web.zoom.us/j/83840850165?pwd=alpPSkVseVJmVWFNaEN0TmZuL1QzQT09
Meeting ID: 838 4085 0165
Access password: 702775

Day 02

Link Zoom:
https://us02web.zoom.us/j/86998298420?pwd=eS9td2dJQXR6ZDBBNHdTeUVQTXlzUT09
Meeting ID: 869 9829 8420
Access password: 766250

Day 03

Link Zoom:
https://us02web.zoom.us/j/81381649342?pwd=N2VGaGlsL293a2xtdzBBaGxLeXBDUT09
Meeting ID: 813 8164 9342
Access password: 449577

Day 04

Link Zoom:
https://us02web.zoom.us/j/85773844815?pwd=TGpON0tXWlQ1bTkzRERkMnVqNlNjUT09
Meeting ID: 857 7384 4815
Access password: 505785

Day 05

Link Zoom:
https://us02web.zoom.us/j/84314359649?pwd=bFY4SU1rTzJGTUloMjFSNW1QNmwyQT09
Meeting ID: 843 1435 9649
Access password: 056378

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General Information

Schedule

6th *TWAS Young Affiliate Network (TYAN) Thematic Workshop in Mathematics and 1st Advanced School in Mathematics*

	Monday (November, 07)	Tuesday (November, 08)	Wednesday (November, 09)	Thursday (November,10)	Friday (November, 11)
08:00-08:30	**Registration**				
08:30-9:00	**Opening** *Paolo Piccione* (Chair of the Organizing Committee) *Helena Nader* (President of the BAS) *Luiz Davidovich* (Secretary-General of TWAS) *Virgilio de Almeida* (Chair TWAS-LACREP) *Sergio Oliva* (Director of IME/USP) *Franco Cabrerizo* (Chair of the Executive Committee TYAN) *Jaqueline Mesquita* (Member of the Executive Committee TYAN)	**Short Courses 1 and 2** Mariel Saez (PUC, Chile) Yoshiharu Kohayakawa (USP, Brazil, TWAS member)			**Free Morning**
09:00-09:30	**Opening talk** *Virgilio de Almeida* (UFMG, TWAS member)				
09:30-10:30	**Short Courses 1 and 2** Mariel Saez (PUC, Chile) Yoshiharu Kohayakawa (USP, Brazil, TWAS member)	**Short Courses 1 and 2** Mariel Saez (PUC, Chile) Yoshiharu Kohayakawa (USP, Brazil, TWAS member)	**Short Courses 1 and 2** Mariel Saez (PUC, Chile) Yoshiharu Kohayakawa (USP, Brazil, TWAS member)	**Short Courses 1 and 2** Mariel Saez (PUC, Chile) Yoshiharu Kohayakawa (USP, Brazil, TWAS member)	

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6th *TWAS Young Affiliate Network (TYAN) Thematic Workshop in Mathematics and 1st Advanced School in Mathematics*

10:30- 11:30	**Coffee break**	**Coffee Break**	**Plenary talk 7** *Ederson Moreira* (ICMC/USP, BAS member)	**Coffee break and Poster Presentation**	
11:30- 12:30	**Plenary talk 1** *Keti Tenenblat* (UnB, TWAS member)	**Plenary talk 4** *Yoshiko Wakabayashi* (USP, BAS member)	**Plenary talk 8** *Daniel Pellegrino* (UFPB, TYAN member)	**Plenary talk 9** *Paulo Cordaro* (IME/USP, TWAS member)	
12:20- 13:30	***Lunch***	***Lunch***	***Lunch***	***Lunch***	
13:30- 14:30	**Plenary talk 2** *Ernesto Lupercio* (Cinvestav, Mexico)	**Plenary talk 5** *Emilio Lauret* (Instituto de Matemática de Bahía Blanca, Argentina)	**Round Table** "*Celebration of 40 years birthday of Revista do Professor de Matemática*" Ana Catarina Hellmeister (member of the editorial board of *Revista do Professor de Matemática*) Pastore de Mello (member of the editorial board of *Revista do Professor de Matemática*) Edmilson Luis Motta (Editor-in Chief of *Revista do Professor de Matemática*) Maria Elisa E. L. Galvão (member of the editorial board of *Revista do Professor de Matemática*) Renate Watanabe (Honorary member of the editorial board of *Revista do Professor de Matemática*	**Plenary talk 10** Helena Nussenzveig Lopes (UFRJ, Brazil, BAS member, TWAS Award in Mathematics 2022)	
14:30- 15:30	**Plenary talk 3** *Jaqueline Mesquita* (UnB, TYAN member)	**Plenary talk 6** *Alexander Arbieto* (UFRJ, TYAN member)		**Plenary talk 11** *Eduardo Teixeira* (University of Central Florida, USA, TYAN member)	**Plenary talk 12** *Gabriela Planas* (IMECC/Unicamp)

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Schedule

6th *TWAS Young Affiliate Network (TYAN) Thematic Workshop in Mathematics and 1st Advanced School in Mathematics*

15:30- 16:00	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*	*Coffee-break*
16:00-18:00	**Round table** "*The actions of Committees of Gender and Diversity*" *Marcia Barbosa* (UFRGS, Member of Committee of Gender and Diversity of TWAS) *Cintya Benedito* (Unesp, Member of Committee of Gender and Diversity of SBM/SBMAC) *Mariel Saez* (PUC/Chile, Member of Colectivo de mujeres matemáticas en Chile) *Christina Brech* (USP, Member of Committee of Gender and Diversity of UMALCA) *Vanderlan da Silva Bolzani* (UNESP, TWAS member, moderator)	**Round table** "*Opportunities for young researchers*" *Gerhard Huisken* (Director of MFO, Oberwolfach, Germany) *Charlotte Grawitz* (EURAXESS Representative) *Roberto Marcondes Cesar Jr* (FAPESP Representative) *Carlos Alberto dos Santos* (CNPq representative) *Irma de Melo-Reiners* (BAYLAT Representative) *Sarah MacLeod* (Heidelberg Laureate Forum representative) *Paolo Piccione* (USP/Brazil, BAS member, Moderator)	**Online Poster Presentation (16:00-17:00)**	**Round table** "*TYAN Panel*" *Jaqueline Mesquita* (Member of EC of TYAN/Brazil) *Leslie Tejeda Perez* (TYAN member, Bolivia, *online participation*) *Federico Bown* (TYAN member, Brazil) *Pablo Bolaños* (TYAN Member, Costa Rica, *online participation*) *Eduardo Teixeira* (TYAN member, USA) (Moderator)	**Round table** "*How can mathematics be used to address global challenges?*" José Alberto Cuminato (USP/São Carlos) Carlile Lavor (IMECC/Unicamp) Nancy Garcia (IMECC/Unicamp) Paulo Artaxo (IF/USP) Roberto Imbuzeiro (Impa) (Moderator) **(Starts at 16:30)**
18:00-19:00	**Welcome Reception**	**Cocktail**			**Closing (Starts at 18:30)**
20:00				**Conference Dinner**	

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The 6th TWAS Young Affiliate Network (TYAN) Thematic Workshop in Mathematics and 1st Advanced School in Mathematics

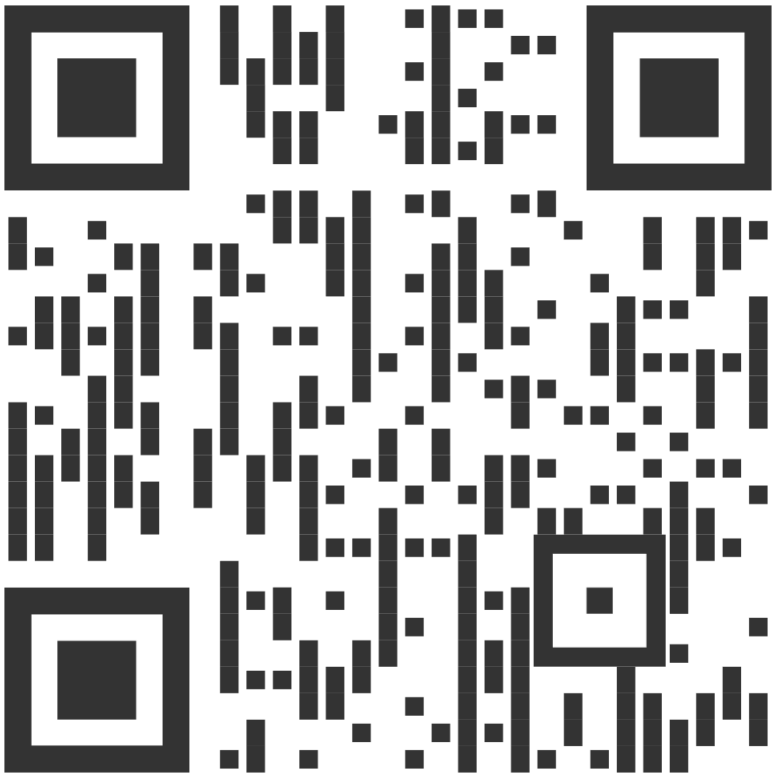
The Thematic Workshop in Mathematics aims to bring together reputed mathematicians to discuss and to promote high level of mathematics in different fields and subjects, with diversity and geographic balance.

It is organized by TYAN (TWAS Young Affiliates Network), TWAS-LACREP (Latin America and the Caribbean Regional Partner of The World Academy of Sciences), The Young Academy of Argentina, The Brazilian Mathematical Society, with the support of the Brazilian Academy of Sciences and Mexican Mathematical Society.

The University of São Paulo (USP), São Paulo campus was the chosen location to host the event. The program, which will be divided over the days between morning, afternoon and evening, will include plenary sessions, mini-courses, round tables and presentation panels.

How to get to the Institute of Mathematics and Statistics?

Link Google Maps: https://goo.gl/maps/8yHo2UohheEYHaTW9



Map of the University of São Paulo

Restaurant map

Places to park

Vagas nas vias

Vagas comuns: 2.269 | Vagas PCD: 67 | Vagas Idosos: 39

Bolsões de Estacionamento

01. Aplicação: 92 Vagas (02 PCD)
02. Educação: 274 vagas (07 PCD, 04 idosos)
03. CEPEUSP: 271 vagas (03 PCD)
04. CRUSP I: 169 vagas (01 PCD)
05. Brasiliana: 95 vagas (06 PCD, 04 idosos)
06. CRUSP II: 55 vagas (06 PCD)
07. SAS Administração: 29 vagas (03 PCD)
08. Poli / CCE: 1.963 vagas (22 PCD, 19 idosos)
09. Poli / Hidráulica: 136 vagas (04 PCD)
10. FEA: 403 vagas (06 PCD, 04 idosos)
11. Psicologia: 330 vagas (09 PCD, 02 idosos)
12. IEE: 170 vagas (04 PCD)
13. IME: 153 vagas (06 PCD)
14. FAU: 293 vagas (03 PCD)
15. FFLCH - Administração: 104 vagas (03 PCD, 09 idosos)
16. Geociências: 109 vagas
17. Semi-Industrial: 104 vagas (01 PCD)
18. FFLCH - Hist. / Geo.: 182 vagas (06 PCD, 05 idosos)
19. FFLCH - Letras / Sociais: 212 vagas (05 PCD, 12 idosos)
20. Química / Farmácia I: 84 vagas (06 PCD)
21. Química / Farmácia II: 507 vagas (01 PCD)
22. Física: 359 vagas (07 PCD)
23. IO: 89 vagas (02 PCD, 05 idosos)
24. HU: 741 vagas (07 PCD)
25. ICB I, II e IV: 574 vagas (11 PCD, 03 idosos)
26. ICB III: 131 vagas (05 PCD, 03 idosos)
27. IB-I: 102 vagas (07 PCD, 08 idosos)
28. IB-II: 198 vagas (09 PCD, 09 idosos)
29. Odontologia: 504 vagas (13 PCD)
30. Veterinária: 380 vagas (10 PCD, 04 idosos)
31. Educação Física - I: 55 vagas (01 PCD)
32. Educação Física - II: 20 vaga (01 PCD)
33. FOFITO: 20 vagas: 53 vagas (02 PCD)
34. Prefeitura - II: 222 vagas (03 PCD)
35. MAE: 26 vagas (03 PCD)
36. Reitoria: 130 vagas
37. Centro de Visitantes: 19 vagas (02 PCD, 01 idosos)
38. FFLCH - Cult. Japonesa: 13 vagas (01 PCD)
39. Clube: 48 vagas (01 PCD)
40. Área Bancária: 261 vagas (13 PCD, 04 idosos)
41. ECA: 83 vagas(03 PCD, 04 idosos)
42. IAG: 239 vagas

Public transport

Below you will find information about the main transport options available:

University City to Butantã Metro:

- 8012-10: Circular 1 / Metrô Butantã – Cidade Universitária
- 8022-10: Circular 2 / Metrô Butantã – Cidade Universitária
- 8032-10: Circular 3 / Metrô Butantã – Cidade Universitária

More information: buspcontato@usp.br or phones (11) 3091-4964 and (11) 3091-4991.

Public transport maps

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Figure 1: Bus 8012-10 departing from the Metro Butantã to the university city

Public transport maps

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Figure 2: Bus 8012-10 departing from the university city to the Metro Butantã

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Figure 3: Bus 8022-10 departing from the Metro Butantã to the university city

Public transport maps

Figure 4: Bus 8022-10 departing from the university city to the Metro Butantã

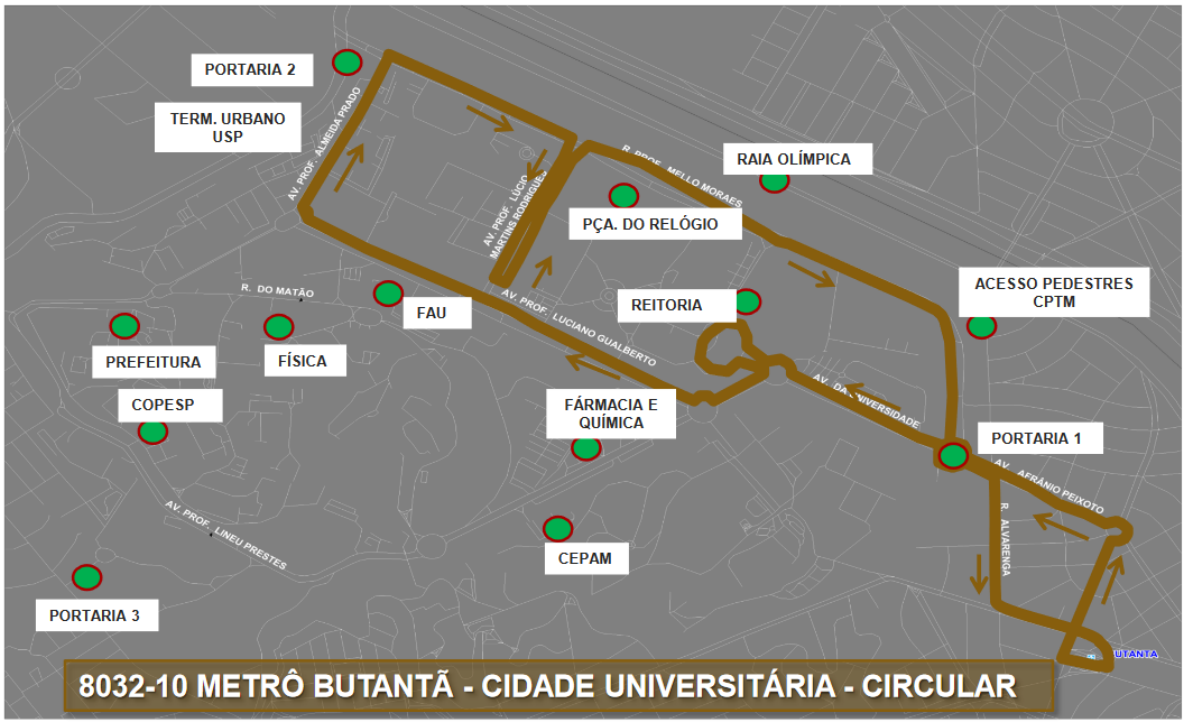

Figure 5: Circular bus 8032-10 traveling from the Metro Butantã to the university city

Public transport to Bovinu'S Churrascaria Rebouças

Conference dinner will take place at the restaurant "Bovinu'S Churrascaria Rebouças", on November 10 at 8pm, below you will find some information about the place and how to get there.

Oficial site: https://bovinus-reboucas.negocio.site/
Date: November, 10, at 8 p.m.

Municipal lines that circulate through the University City:

University City to Bovinu'S Churrascaria Rebouças:

- 177H-10: Metrô Santana – Butantã USP
- 7411-10: Pça. da Sé – Cidade Universitária
- 702U-10: Term. Pq. D. Pedro II – Butantã USP
- 701U-10: Metrô Santana – Butantã USP

Departure place: 976 Av. Professor Luciano Gualberto

Figure 6: Location of Bovinu'S Churrascaria Rebouças

Taxi:
University City has three taxi ranks:

- Rectory Square – Fone: (11) 3091-3556;
- Praça das Agências Bancárias – Fone: (11) 3091-4488;
- University Hospital – Fone: (11) 3091-3536.

The fleets operate from Monday to Friday, from 07:00 to 23:00, and on Saturdays, from 07:00 to 17:00.

Access the QR CODE on the side for more information on how to get to Bovinu'S Churrascaria Rebouças

Restaurant Options at USPs

Lanchonete da física:

Menu: https://lanchonetedafisica.goomer.app/menu
Infos: https://lanchonetedafisica.goomer.app/about
Instagram: https://www.instagram.com/lanchonetedafisica/

Restaurante da FAU:
https://restaurantguru.com.br/Cooperativa-Monte-Sinai-Lanches-Sao-Paulo

Restaurante da FEA USP: https://www.tripadvisor.com.br/Restaurant_Review-g303631-d4528498-Reviews-Sweden-Sa_Paul_State_of_Sao_Paulo.html

Plenary Speakers

On Expansive Systems

Alexander Arbieto- TYAN Member (Federal University of Rio de Janeiro, Brazil) Rio de Janeiro, Brazil

Abstract

In this talk we will present the theory of expansiveness for dynamical systems. We will show how the theory is well developed for homeomorphisms and diffeomorphisms, and we will relate it with the concept of entropy. We will show the advances for flows and explain how the theory still has open questions for flows with singularities. If the time allows, we will talk about some recent results for group actions.

Plenary talk 6:

Tuesday (November, 08), $14:30-15:30$

The unbalancing lights problem

Daniel Pellegrino - TYAN Member (Federal University of Paraíba)
João Pessoa, Brazil[1]

Abstract

The unbalancing lights problem (sometimes called Gale-Berlekamp switching game) consists of an $n \times n$ square matrix of light bulbs set up at an initial configuration Θ_n. The board (matrix) has n row and n column switches, which invert the on-off state of each bulb (on to off and off to on) in the corresponding row or column. Let $i(\Theta_n)$ denote the smallest final number of on-lights achievable by row and column switches starting from Θ_n. The goal is to find

$$R_n := \max\{i(\Theta_n) : \Theta_n \in \mathcal{P}\},$$

where $\mathcal{P}$ is the set of all 2^{n^2} initial configurations. We investigate upper and lower estimates for R_n. This talk is based in joint works with A. Raposo, J. Silva and E. Teixeira.

Plenary talk 8:

Tuesday (November, 09), $11:30 - 12:30$

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Departamento de Matemática, Universidade Federal da Paraíba, 58.051-900 - João Pessoa, Brazil, e-mail: daniel.pellegrino@academico.ufpb.br

Sublinear type elliptic PDEs

Ederson Moreira dos Santos - Bas Member (ICMC/ University of São Paulo)
São Carlos, Brazil

Abstract

In this lecture I will address some questions regarding existence, uniqueness, qualitative properties and characterization of special solutions of elliptic PDEs, namely least energy solutions and least energy nodal solutions. I will be more focused on our recent contributions about sublinear type elliptic PDEs and show that some of these results can be set on a general framework on critical point theory.

Plenary talk 7:

Tuesday (November, 09), $10:30 - 11:30$

Understanding the regularity mechanism of nonlinear diffusion processes

Eduardo Teixeira -TYAN Member (University of Central Florida)
United States

Abstract

Nonlinear diffusion processes drive a plethora of fundamental phenomena in Nature, ranging from physics, to chemistry, biology and finances. A key feature of such models is that their corresponding regularity mechanisms are relatively mild in comparison to their linear counterparts. The mathematical manifestation of such a deficiency is the eventual lack of differentiability of solutions. In this talk, I will discuss a necessary condition on the " diffusion resistance" of the model as to attain C^1 regularity of solutions. Since C^1-estimate is a borderline regularity case, this is notoriously more difficult and the analysis requires several new ingredients, which will be discussed by geometric means.

Plenary talk 10:

Tuesday (November, 10), $14:30-15:30$

Survey of isospectral homogeneous Riemannian manifolds

Emílio Lauret (Instituto de Matemática de Bahía Blanca)
Argentina

Abstract

We will review several results on inverse spectral geometry in the setting of homogeneous Riemannian manifolds. Some key points will be Schueth's examples of continuous curves of isospectral left-invariant metrics on compact Lie groups, Sutton's construction of isospectral compact homogeneous Riemannian manifolds (as a generalization of Sunada-Pesce's method), and spectral isolation/uniqueness problems among $G-$invariant metrics on a fixed homogeneous space G/K.

Plenary talk 5:

Tuesday (November, 8), $13:30-14:30$

Self-organization at the origin of artificial life

Ernesto Lupercio - BYAN Member (Centro de Investigación y de Estudios Avanzados Del IPN)
Mexico

Abstract

In this talk, aimed at a general audience, we will do a very brief review of the fields of artificial life and self-organized criticality and finally see how the second informs the first, enhancing our understanding of biological systems. This talk is based on joint work with Kalinin and Shkolnikov, and with Cruz, Muñoz, Tabares, and Viafara.

Plenary talk 2:

Tuesday (November, 7), $13:30-14:30$

Decay of solutions to the Navier-Stokes equations

Gabriela Planas (Estadual University of Campinas)
Campinas, Brazil

Abstract

The Navier-Stokes equations describe the time evolution of the velocity of an incompressible fluid. The Fourier Splitting Method is the main tool for proving the energy decay of the solutions. In this talk, we will present some ideas behind this study and discuss recent results in critical Sobolev spaces.

Plenary talk 11:

Tuesday (November, 11), $14:30-15:30$

Transport theory and applications to fluid dynamics

Helena Nussenzveig Lopes - TWAS Award 2022 (Federal University of Rio de Janeiro)
Rio de Janeiro, Brazil

Abstract

The underpinning of classical theory of ODEs and transport equations is smooth vector fields. In seminal work, published in 1989, Ron DiPerna and Pierre-Louis Lions provided an extension of this theory to vector fields with Sobolev regularity. This was motivated in great part by problems in kinetic theory and in turbulence.

In this lecture we will introduce some of the main ideas and results from the DiPerna-Lions transport theory. We will then present and discuss applications in incompressible fluid dynamics connected to the mathematical modeling of turbulence.

Brief introduction to functional differential equations, dynamic equations on time scales and generalized ODEs

Jaqueline Godoy Mesquita - TYAN Member (University of Brazilia)
Brazilia, Brazil

Abstract

In this talk, I will give a brief introduction of functional differential equations, dynamic equations on time scales and generalized ODEs, as well as to present some applications that can be addressed using these equations.

Plenary talk 3:

Tuesday (November, 7), $14:30-15:30$

Geometric Bäcklund Transformations and Superposition Formulae for the hyperbolic and elliptic sine-Gordon and sinh-Gordon equations

Keti Tenenblat - TWAS Member (University of Brazilia)
Brazilia, Brazil

Abstract

We present a unified approach for the six cases of Bäcklund-type theorems for space-like or time-like surfaces, in the 3−dimensional pseudo-Euclidean space. In each case, the surfaces have constant negative or positive Gaussian curvature and they correspond to solutions of the hyperbolic or elliptic sine-Gordon or sinh-Gordon equations. We discuss Bäcklund transformations and obtain superposition formulae for these equations. This procedure provides infinitely many solutions of the differential equations and it shows an unusual property for the elliptic equations. The Bäcklund transformation alternates solutions of the elliptic sinh-Gordon equation with those of the elliptic sine-Gordon equation and the superposition formula provides solutions of the same elliptic equation. Explicit examples and illustrations are included and the singularities of the solutions are briefly discussed. This talk is based on recent papers in collaboration with Filipe Kelmer and Luciana A. Rodrigues.

Plenary talk 1:

Tuesday (November, 7), $11:30 - 12:30$

The Borel map and the algebra of smooth solutions in locally integrable structures

Paulo Cordaro - TWAS Member (IME/University of São Paulo)
São Paulo, Brazil

Abstract

In this talk we shall present the concept of a locally integrable structure, the associate algebra of solutions, its Borel map and show how the algebraic properties of the Borel map induce analytic properties of the solutions. This is a long term research project developed in collaboration with B. Lamel (Qatar) and G. DellaSala (Lebanon).

Plenary talk 9:

Tuesday (November, 10), $11:30-12:30$

On packing of circles and spheres

Yoshiko Wakabayashi - BAS Member (IME/University of São Paulo)
São Paulo, Brazil

Abstract

Problems on packing of circles and spheres have attracted great attention of mathematicians and have been investigated for many centuries.

One of the oldest and most famous packing problems concerns a question on the densest possible arrangement of unit spheres in the 3-dimensional Euclidean space. A solution to this problem was conjectured by Kepler in 1611, but proved only in 2005 by Hales.

Except for the dimension 2 (solved by Fejes-Tóth, 1942), the corresponding problems in other dimensions remained open until 2017, when Maryna Viazovska, one of the Fields Medal winners 2022, solved in dimension 8. This breakthrough contributed to a solution in dimension 24 (Cohn, Kumar, Miller, Radchenko and Viazovska, 2017).

Many other types of packing problems have been considered in the literature. Some of them have attracted more attention of computer scientists, interested both in theoretical issues concerning their computational complexity, as well as more practical issues concerning the design of algorithms to solve them.

Most classical packing problems are NP-hard, and therefore unlikely to be solvable in polynomial time. In this talk we focus on one such problem: given a finite set of circles of different sizes, pack them into a smallest possible number of unit bins. We present an asymptotic polynomial-time approximation scheme for this problem (that can be extended to packing of spheres into cubes, and other related cases).

This is joint work with Flávio K. Miyazawa (Unicamp), Lehilton L.C. Pedrosa (Unicamp), Rafael C.S. Schouery (Unicamp) and Maxim Sviridenko (Yahoo Research).

Plenary talk 4:

Tuesday (November, 8), $11:30 - 12:30$

Mini-courses

Eigenvalues of operators in conformal geometry

Mariel Saez (Pontificia Universidad Católica de Chile)
Región Metropolitana, Chile

Abstract

The study of spectral properties of differential operators has an extensive history and draws connections with several fields of mathematics. In this mini-course we will explore spectral properties of certain operators that are related to conformal geometry and their connections with topology. We will specially focus on three examples: The Laplace-Beltrami operator in two dimensions, the Dirichlet-to-Neumann map associated with it and the Paneitz operator. We will finish the discussion with some open problems.

Schedule

	Monday (November, 07)	Tuesday (November, 08)	Wednesday (November, 09)	Thursday (November, 10)
08:30 – 09:30		Mini- Course 01		
09:30 – 10:30	Mini- Course 01	Mini- Course 01	Mini- Course 01	Mini- Course 01

;

A first look at quantum computing and quantum information

Yoshiharu Kohayakawa
TWAS Member (IME/University of São Paulo, Brazil)
São Paulo, Brazil

Abstract

This will be a short course for non-specialists by a non-specialist. We shall study classical quantum algorithms (such as Shor's factorization algorithm), approaching them via a standard mathematical model that can be understood without the physics involved. We shall also discuss some quantum variants of combinatorial parameters, such as the chromatic number of a graph. Those variants highlight the power of entanglement.

Schedule

	Monday (November, 07)	Tuesday (November, 08)	Wednesday (November, 09)	Thursday (November, 10)
08:30 – 09:30		Mini- Course 02		
09:30 – 10:30	Mini- Course 02	Mini- Course 02	Mini- Course 02	Mini- Course 02

Posters

A discontinuous differential calculus in the framework Colombeau's full algebra

Antonio Ronaldo Gomes Garcia
Brazil

Abstract

Starting from Colombeau's full generalized functions, the sharp topologies, and the notion of generalized points, we introduce a new kind of differential calculus (for functions between totally disconnected spaces). We study generalized point values, Colombeau's differential algebra, and holomorphic and analytic functions. We show that the Embedding Theorem and the Open Mapping Theorem hold in this framework. Moreover, we study some applications in differential equations.

Kurzweil Integral and Generalized ODEs

Aryel Araújo[2](Department of Mathematics, University of Brasilia)
Brasilia, Brazil

Abstract

In this work we will investigate the development of some types of Integral, like de Henstock-Kurzweil, defined as:

A function $f : I \to \mathbb{R}$ is said to be Henstock-Kurzweil-Integrable on I if there exists a number $B \in \mathbb{R}$ such that for every $\epsilon > 0$, there exists a gauge γ_ϵ on I such that if $\dot{P} := (I_i, t_i)_{i=1}^n$ is any tagged partition of I such that $l(I_i) < \gamma_\epsilon(t_i)$ for $i = 1, ..., n$, then

$$|S(f; \dot{P}) - B| \leq \epsilon$$

The model proposed by Henstock started from the investigation of an integration process with the objective of reconstructing a derived function, and is responsible for covering a broader class of functions than those present in the Riemann and Lebesgue models, without the need to work with measure theory, as in Lebesgue-Integrable functions.

This model naturally pays more attention to the tags than the more traditional integration models, so, the concept is constructed by allowing the $\gamma_\epsilon > 0$, used in the definition of the Riemann Integral, be any positive function, this allows a wider class of functions to be integrable.

[2]Under the guidance of Professor Jaqueline Godoy Mesquita

TBA

Elvis da Silva Rodrigues
Brazil

Abstract

TBA

Hyperbolic manifolds with a large kissing number

Emanoel Freire
Brazil

Abstract

A hyperbolic $n-$manifold is a $n-$dimensional manifold without boundary, equipped with a complete Riemannian metric of constant curvature -1. Any hyperbolic manifold is isometric to a quotient space $M = \Gamma\backslash\mathbb{H}^n$, where $\mathbb{H}^n$ is the hyperbolic $n-$space and Γ is a torsion-free discrete group of isometries of $\mathbb{H}^n$.

Recent developments have turn out the attention to the search of hyperbolic manifolds with some extremal properties. For example, such spaces with minimal volume [Bel14], minimal diameter [BCP21], large systole [Mur19] and large kissing number. We are interested in hyperbolic manifolds with large kissing number, and their relation with its systole and volume.

It is well known that any finite volume hyperbolic manifold M contains closed geodesics, and there exists at least one of minimal lengthwhich is called a systole of M. The length of any systole of M will be denoted by $\mathrm{sys}(M)$.

We define the kissing number $\mathrm{Kiss}(M)$ of M as the number of systoles of M. This is a well-defined invariant since, in negative curvature there are finitely many closed geodesics with the same length. This terminology was introduced by Schmutz Schaller, and it was inspired by the classical kissing number of lattices arising in sphere packings (see [Sch96a],[Sch96b],[Sch]).

Recently, Bourque and Petri proved an upper bound of $\mathrm{Kiss}(M)$ which does not depend on the size of $\mathrm{sys}(M)$ (see [BP22, Theorem 1]). More precisely,

$$\mathrm{Kiss}(M) \leq A_n \mathrm{vol}(M) \frac{\exp\left(\frac{n-1}{2}\mathrm{sys}(M)\right)}{\mathrm{sys}(M)} \tag{1}$$

It is important to mention that Inequality (1) is weaker than the results obtained from [Kee74] and [Bus80] for small systole. However, if $\mathrm{sys}(M)$ is large, the Inequality (1) implies that

$$\mathrm{Kiss}(M) \leq B_n \frac{\mathrm{vol}(M)^2}{\log(1+\mathrm{vol}(M))} \tag{2}$$

These restrictions for $\mathrm{Kiss}(M)$, motivated us to study the following question formulated in [Pet]: Let $n \geq 2$ and

$$K_n(v) = \max\{\mathrm{Kiss}(M) | M \text{ is a hyperbolic } n-\text{manifold of } \mathrm{vol}(M) \leq v\}.$$

Question 1. How does $K_n(v)$ grows as a function of v?

Although this question is independent on the size of $\mathrm{sys}(M)$, it is interesting to understand $\mathrm{Kiss}(M)$ according to whether $\mathrm{sys}(M)$ is small or large.

The main part of the work is devoted to give an answer to 1 independently on the size of the systoles. For $n = 2$, it follows from results by Schmutz in [Sch] that

$$\limsup_{v\longrightarrow\infty}\frac{\log K_2(v)}{\log v}\geq 1+\frac{1}{3} \tag{3}$$

To prove this result, the author constructed a sequence S_i of closed (also non-compact of finite area) hyperbolic surfaces with large kissing number as congruence coverings of a fixed arithmetic hyperbolic surface. It is worth to note that the surfaces Si also satisfy

$$\mathrm{sys}(S_i)\sim\frac{4}{3}\log(\mathrm{area}(S_i))\longrightarrow\infty$$

where $i\longrightarrow\infty$.

More generally, if a sequence M_i of non-diffeomorphic closed hyperbolic $n-$manifolds has $\mathrm{Kiss}(M)$ growing super linearly in $\mathrm{vol}(M_i)$, then $\mathrm{sys}(M_i)$ grows logarithmically in $\mathrm{vol}(M_i)$.

In [Mur19], the author showed that congruence coverings of closed arithmetic hyperbolic $n-$manifold of the first type have systole with length growing logarithmically in the volume, and determined the precise growth ratio. It is then natural to investigate the kissing number of such manifolds, and to ask whether they can provide a version of (3) in higher dimension. In this direction we obtain the following.

Theorem 1 *For any $n\geq 2$, there exists a compact arithmetic hyperbolic $n-$manifold of first-type M, and a sequence of congruence coverings $M_j\longrightarrow M$ of arbitrarily large degree such that*

$$\mathrm{Kiss}(M_j)\geq C\frac{\mathrm{vol}(M_j)^{1+\frac{1}{3n(n+1)}}}{\log(\mathrm{vol}(M_j))} \tag{4}$$

for some constant $C>0$ independent of M_j.

Although the systolic length of congruence coverings of arithmetic manifolds is large, exhibiting the systoles in these spaces is a much more delicate problem. We turns this by constructing M_j containing a totally geodesic surface S_j whose systoles are also systoles of M_j.

Theorem 2 *For any $n\geq 3$, the manifold M obtained in Theorem 1 contains a closed totally geodesic surface S such that for any j, the congruence coverings $M_j\longrightarrow M$ contains a congruence covering $S_j\longrightarrow S$ satisfying $\mathrm{sys}(S_j)=\mathrm{sys}(M_j)$.*

Once more, the technique includes ideas by Schmutz, but a new length-trace relation was needed, and also a result on averages of class numbers of imaginary binary forms proved by Sarnak. These results are no longer available in the compact setting. Instead, we have now been able to use the holonomy of closed geodesics. We are able to construct arithmetic hyperbolic 3-manifolds with a large number of systoles using the relation between length and trace of 2×2 matrices, and a result of equidistribution of closed geodesics with holonomy in prescribed intervals proved by Sarnak and Wakayama in [SW99] (see also [MMO14]). We finish the work with the proof of the following theorem.

Theorem 3 *There exists a sequence $\{M_j\}$ of compact arithmetic hyperbolic $3-$manifold with $\mathrm{vol}(M_j)$ going to infinity such that*

$$\mathrm{Kiss}(M_j)\geq C\frac{\mathrm{vol}(M_j)^{4/3}}{\log(\mathrm{vol(M_j)})}$$

where $C>0$ is a universal constant.

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Minimal intrinsically homogeneous submanifolds of hyperbolic space in codimension two

Felippe Guimaraes
Brazil

Abstract

We shown that minimal intrinsically homogeneous submanifolds in the hyperbolic space up to codimension two are either totally geodesic or a particular extrinsic warped product. Joint work with Joeri Van der Veken

Hausdorff dimension of Julia sets of quadratic functions

Gabriela C. Silva[3] and Denis A. P. Garcia[4] (IME/University of São Paulo Brazil

Abstract

In this work, we firstly present the self-similar fractals, introduced in [1], and then we state Moran's Theorem and its version for contractions. Moran's Theorem is closely related to the concept of iterated function system. An iterated function system (IFS) consists of a complete metric space (X, d) equipped with a finite collection $\{S_1, \ldots, S_k\}$ of contractions from X into X and will be denoted by $\big\{(X, d); S_1, \ldots, S_k\big\}$. In general, fractals are defined as fixed points of iterated function systems. Defining fractals using an IFS makes it easier to calculate their Hausdorff dimension, as many fractals are collections of copies of themselves. Associated with an IFS, we consider the set $\mathcal{K}(X) := \{A \subseteq X : A \text{ is compact}\}$ and the Hutchinson operator $\mathcal{H}\colon \mathcal{K}(X) \to \mathcal{K}(X)$, which, for each $K \in \mathcal{K}(X)$, associates the set $\bigcup_{j=1}^{k} S_j(K)$. An elegant application of Banach's fixed point theorem shows that there is a unique nonempty compact set $\mathcal{F} \subseteq \mathbb{R}^n$ such that $\mathcal{F} = \bigcup_{i=1}^{k} S_i(\mathcal{F})$. We say that the set $\mathcal{F}$ (which is a self-similar fractal) is an IFS-invariant set, and the Moran-Hutchinson Theorem assures us that, if $S_1, \ldots, S_k$ are similarities that satisfy the open set condition (see [1]), then the similarity dimension of $\mathcal{F}$ — which is the unique real number s such that $\sum_{i=1}^{k} \lambda_i^s = 1$ — equals its Hausdorff dimension, which we will denote by $\dim_H \mathcal{F}$. After presenting the classical version of Moran's Theorem, we use Moran's Theorem for Contractions — which is nothing more than a version of Moran's Theorem in which similarities are replaced by contractions — to show that, if $c \in \mathbb{C}$, then $\dim_H \big(J(f_c)\big) \simeq \frac{2\log(2)}{\log(4|c|)}$, where $J(f_c)$ is the Julia set of the quadratic function $f_c\colon \mathbb{C} \to \mathbb{C}$ such that $f_c(z) := z^2 + c$ for any $z \in \mathbb{C}$.

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The constrained Knapsack problem

Giovana Melo dos Santos[5] (Department of Mathematics, State University of Maringá) Maringá Brazil

Abstract

The knapsack problem intends, given a set of items with specific weight and values and a knapsack with limited weight capacity, to find a subset of items such that the total value is maximized subject to the capacity restriction.

We are working with a classic discrete linear programming problem intensively investigated and frequently present in more complex problems. We aim in this work, to model and solve the Hunger Games Problem(HGP)[1], a more complex version of the knapsack problem, using linear and integer programming. Moreover, it will be discussed two algorithm formulations for the HGP and its computational implementations in the modeling language JuMP.

In the Hunger Games Problem, there is a girl, Katniss, that needs to survive one night in the forest and has 20 items arranged in her surroundings. Katniss looks forward to maximizing her chance of survival and is aware that she is capable of carrying only 30 kg in her knapsack and the time available is limited to 30 min by the sunset.

Item	Description	Weight	Survival value	Item	Description	Weight	Survival value
1	Sleeping bag	9	15	11	Arrows	5	10
2	Dried beef strips	5	14	12	Flint	6	9
3	Nuts	3	10	13	Towel	1	2
4	Bow	10	25	14	Tent	25	50
5	Night vision glasses	10	15	15	Coiled wire	7	5
6	Slingshot	10	3	16	Bottle of iodine	5	12
7	Peeta's medicine	15	30	17	Extra pair of socks	4	10
8	Flashlight	3	5	18	Matches	1	2
9	Knife	3	7	19	Mockingjay Pin	2	2
10	Water	5	15	20	Rain jacket	12	25

Table 1: Weight in kg and survival value of each item

Katniss location and each item coordinates are provided. She can move up/down/left/right but not diagonally and each step takes 1 minute. The question we aim to answer is: what is the optimal combination of items(with the greatest survival value) that obeys to the restrictions of capacity and maximum travel time? To respond such question we investigated the LP modeling of two aspects of the problem and its connections: the selection of an optimal set of items and the determination of a path to be traveled upon this set. In the first case, the corresponding integer programming problem(IPP) resumes to the classical knapsack problem, i.e., we will consider binary variables $x_i,\ i = 1, ..., 20$ that represent the presence or absence of item i when $x_i = 1$ or 0. In addition, we will denote by s_i and p_i the survival value and weight of the respective item. Thus, we want to optimize the sum of the survival values subject to total weight restriction of 30 kg, therefore we have

[5]Under the guidance of Professor Francisco Nogueira Calmon Sobral

$$\begin{aligned} \text{Maximize} \quad & \sum_{i=1}^{20} s_i x_i \\ \text{subject to} \quad & \sum_{i=1}^{20} p_i x_i \leq 30, \qquad i = 1, \ldots, 20 \\ & x_i \in \{0,1\}, \quad i = 1, \ldots, 20 \end{aligned}$$

So, obtained an optimal set of items from the IPP above it is possible to verify the existence and viability of a path that passes through all of them making use of a mixed linear programming modeling for the Traveling Salesman Problem.

Given the graph generated by the solution of this IPP(the one which vertices are the starting point and the selected items and edges all possible links between all vertices), the model acts deriving the lowest cost Hamiltonian circuit upon the graph making use of binary variables x_{ij} to indicate the presence or absence of the route between vertices i and j, where $i, j = 1$ represents the origin. We also consider c_{ij} the travel time between vertices i and j and link the indices $i = 2, \ldots, n$, where n is equal to the quantity of vertices of the graph, to the items of the optimal set. Therefore, to find this circuit we demand Katniss to leave and arrive at each vertex once, which means $\sum_{j=1}^{n} x_{kj} = 1$ e $\sum_{i=1}^{n} x_{ik} = 1$ for $k = 1, \ldots, n$. Sub-route elimination restrictions are also needed and expressed by the following inequalities: $u_i - u_j + (n+1)x_{ij} \leq n$, $i, j = 2, \ldots, n,\ i \neq j$ where $u_i \geq 0,\ i = 2, \ldots, n$ are continuous variables. Consequently, the problem of minimizing the total cost of the path except the return to the origin selecting routes between items of the optimal set can be formulated mathematically as

$$\begin{aligned} \text{Minimize} \quad & \sum_{i=1}^{n}\sum_{j=2}^{n} c_{ij} x_{ij} \\ \text{subject to} \quad & \sum_{i=1}^{n} x_{ik} = 1, && k = 1, \ldots, n \\ & \sum_{j=1}^{n} x_{kj} = 1, && k = 1, \ldots, n \\ & u_i - u_j + (n+1)x_{ij} \leq ni, j = 2, \ldots, n,\ i \neq j \\ & x_{ij} \in \{0,1\}, && i, j = 1, \ldots, n \\ & u_i \geq 0 && i = 2, \ldots, n \end{aligned}$$

Acknowledgements

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Summary About Varieties of polynomial growth

Kauê Orlando Pereira
Brazil

Abstract

We discuss algebras satisfying polynomial identities. More precisely we consider an approach to the classification of the ideals of polynomial identities for a algebra A over a field K of characteristic zero.

In 1950, W. Specht posed in [7], a problem that later became widely known as the "Specht problem". Namely he asked whether for every associative algebra A over a field of characteristic 0, its ideal of identities in the free associative algebra, is finitely generated as an ideal of identities. The solution turned out to be quite difficult, and only around 1985, Kemer gave the positive answer to the Specht problem, see for example [5]. To that end Kemer developed a powerful theory which showed that the ideals of identities ($T-$ideals) behave in a way similar to that of the ideals of the ordinary associative and commutative algebra of polynomials in several variables. Kemer's proof is not constructive, and describing a finite generating set (also caled a basis) of the identities of a given algebra is extremely difficult. We only mention that we have not a slightest idea what a basis of the identities of the $n \times n$ matrix algebra looks like, not even for $n = 3$.

Thus describing the concrete form of the identities satisfied by an algebra is not a feasible task. A combinatorial approach to PI algebras was developed by Amitsur and later on used with great effect by Regev. It is based on the following observations. Since our field is of characteristic 0 one can study the multilinear polynomials only: it can be proved that the identities satisfied by an algebra follow from the multilinear ones. Denote by P_n the vector space in the free associative algebra spanned by the first n variables. It is a left module over the symmetric group S_n, acting on P_n by permuting the variables. Recall that P_n is canonically isomorphic to the regular S_n-module, and $\dim P_n = n!$.

If $I = T(A)$ is the $T-$ideal of an algebra A then $I \cap P_n$ is a submodule of P_n, and one can employ the well developed theory of representations of the symmetric group Sn in order to study polynomial identities. In effect it is better to study the factor module $P_n(A) = P_n/(I \cap P_n)$. Denote by $c_n = c_n(A) = \dim P_n(A)$ the $n-$th codimension of A. Regev proved that if A is PI then there exists a constant d such that $c_n(A) \leq d^n$ for every n. (Hence $I \cap P_n$ is very close to the whole P_n as long as n is large enough.) Around 1980, Amitsur suggested that the limit $lim_{n \longrightarrow \infty}(c_n(A))^{1/n}$ exists for every PI algebra A, and is an integer. In 1998–99, Giambruno and Zaicev proved that Amitsur's conjectureholds. Nowadays the asymptotic behaviour of the codimension sequence is quite tightly described.

Hence one may want to classify the PI algebras according to their PI exponent. This is an important and very active area of research in PI theory. An interesting problem is the description of the T-ideals whose codimensions grow slowly, like polynomial functions. A theorem of Kemer gives us that the codimensions grow either exponentially of polynomially, that is no intermediate growth is possible.

Here we shall discuss the main methods in the asymptotic theory of PI algebras. These are based on Kemer's theory: every PI algebra A satisfies the same identities as the Grassmann envelope of a finite dimensional superalgebra. Moreover, if an algebra is of polynomial growth of its codimensions, then it satisfies the same identities as some finite dimensional algebra. Several other deep theorems are necessary in such a study: the Wedderburn–Malcev decomposition, various results concerning the representations of the symmetric (and general linear) groups. We shall give several characterizations of the identities satisfied by an algebra whose codimensions have polynomial growth.

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The TYAN organization thanks all speakers and participants!!

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