Book of abstracts

3rd BYMAT CONFERENCE

Bringing Young Mathematicians Together

DECEMBER 1-3, 2020

BYMAT

Bringing Young Mathematicians Together

Organising Committee:

- Patricio Almirón Cuadros (Universidad Complutense de Madrid)
- Clara Burgos Simón (Universitat Politècnica de València)
- José Alberto Conejero Casares (Universitat Politècnica de València)
- Alberto Espuny Díaz (Technische Universität Ilmenau)
- Elena López Navarro (Universitat Politècnica de València)
- David Martínez Rodríguez (Universitat Politècnica de València)
- Ana Navarro Quiles (chair, Universitat de València)
- Eva Primo Tárraga (Universidad Rey Juan Carlos)
- Miguel Reula Martín (Universitat de València)

Scientific Committee:

- Juan Carlos Cortés López (Universitat Politècnica de València)
- Adrián Hinojosa Calleja (chair, Universitat de Barcelona)
- Marta de León Contreras (University of Reading)
- Consuelo Parreno Torres (Universitat de València)
- Victoria Ponce Bobadilla (Universität Heidelberg)
- Tomás Sanz Perela (University of Edinburgh)
- Erik Sarrión Pedralva (Universitat Jaume I)
- Josué Tonelli Cueto (INRIA Paris/ IMJ-PRG)

Steering Committee:

- Ángela Capel (Technische Universität München)
- Patricia Contreras Tejada (Instituto de Ciencias Matemáticas-CSIC)
- Roi Naveiro (Instituto de Ciencias Matemáticas-CSIC)
- Jesús Ocáriz (Instituto de Ciencias Matemáticas-Universidad Autónoma de Madrid)

	TUESDAY - 1st December 2020								
09:00 - 09:30	**Opening session**								
09:30 - 10:30	**Plenary - Kit Yates**								
10:30 - 11:00	**Break**								
11:00 - 13:00	**Parallel sessions**								
	Algebra: Session 1	Algebraic and complex geometry: Session 1	Analysis and operator algebras: Session 1	Combinatorics: Session 1		Geometry: Session 1	Mathematical physics: Session 1	PDEs: Session 1	Probability and statistics: Session 1
13:00 - 14:00	**Lunch**								
14:00 - 15:00	**BYMAT meeting**								
15:00 - 17:00	**Parallel sessions**								
	Algebra: Session 2	Algebraic and complex geometry: Session 2	Analysis and operator algebras: Session 2	Combinatorics: Session 2	Dynamical systems and ODEs: Session 1	Geometry: Session 2	Mathematical physics: Session 2	PDEs: Session 2	Probability and statistics: Session 2
17:00 - 18:30	**FBBVA session: Covid 19 – round table**								

	WEDNESDAY - 2nd December 2020								
09:30 - 10:30	**Plenary - María Medina**								
10:30 - 11:00	**Break**								
11:00 - 13:00	**Parallel sessions**								
	Algebra: Session 3	Analysis and operator algebras: Session 3	Combinatorics: Session 3	Control theory and optimization: Session 1	Dynamical systems and ODEs: Session 2	Geometry: Session 3	Mathematical aspects of computer science: Session 1	Applied Mathematics: Session 1	PDEs: Session 3
13:00 - 14:00	**Lunch**								
14:00 - 15:00	**Plenary - Davide Barbieri**								
15:00 - 16:30	**Workshop - Marc Noy**								
16:30 - 18:30	**Poster session**								

	THURSDAY - 3rd December 2020							
09:30 - 10:30	**Plenary - Marina Murillo**							
10:30 - 11:00	**Break**							
11:00 - 12:30	**IBM Workshop - Carmen Recio**							
12:30 - 14:00	**Lunch**							
14:00 - 15:00	**Plenary - Carolina Vallejo**							
15:00 - 17:00	**Parallel sessions**							
	Algebraic and complex geometry:	Analysis and operator algebras:	Combinatorics:	Control theory and optimization:	Dynamical systems and ODEs:	Number theory:	Applied Mathematics:	Topology:
	Session 3	Session 4	Session 4	Session 2	Session 3	Session 1	Session 2	Session 1
17:00 - 18:30	**Workshop - Juan Miguel Ribera**							
18:30 - 19:00	**Closure – social activity (online)**							

Invited talks

Tuesday

9:30 - 10:30

Modelling development in biology

Kit Yates, University of Bath
cy386@bath.ac.uk

Spatial reaction-diffusion models have been employed to describe many emergent phenomena in biological systems. The modelling technique for reaction-diffusion systems that has predominated due to its analytical tractability and ease of simulation has been the use of partial differential equations (PDEs). However, due to recent advances in computational power, the simulation, and therefore postulation, of computationally intensive individual-based models has become a popular way to investigate the effects of noise in reaction-diffusion systems.

In a wide variety of biological situations, computationally-intensive, high-resolution models are relevant only in particular regions of the spatial domain. In other regions, coarser representations may suffice to capture the important dynamics. Such conditions necessitate the development of hybrid models in which some areas of the domain are modelled using a coarse-grained representation and others using a more fine-grained representation.

In this talk I will discuss recent work from my group on connecting coarse and fine representations of reaction-diffusion phenomena. The models to be coupled will include both on and off-lattice individual-based representations of diffusion with and without volume exclusion as well as macroscopic partial differential equations. In each scenario we will demonstrate good agreement between our hybrid models and the full individual-based representation whilst achieving significant computational savings.

Wednesday

9:30 - 10:30

Solving elliptic PDEs: variational and reduction methods

María Medina, Universidad Autónoma de Madrid
maria.medina@uam.es

A fundamental issue in the theory of Partial Differential Equations is the existence of solutions for a given equation. Establishing general conditions and results to ensure solvability is the central line of the field, and in this talk we will analyze several ways to face elliptic PDEs. We will go through two families of techniques: variational methods, where we transform the existence of solution to our problem into the existence of a critical point for a given functional, and Lyapunov-Schmidt methods, aimed to reduce the existence matter to finding a solution to an associated finite dimensional problem.

14:00 - 15:00

Harmonic analysis on groups and applications

Davide Barbieri, Universidad Autónoma de Madrid
davide.barbieri@uam.es

The design and application of results in abstract harmonic analysis for the study of symmetries in datasets like digital sounds and images constitutes an active research field with a long history. Besides abelian groups such as the group of translations, of special importance due to its natural relationship with convolution and Fourier analysis, several nonabelian group structures have proved to be relevant in applications. The simplest ones are the Heisenberg group of quantum mechanics and the affine group of the Euclidean space, which give rise to the so-called Gabor and wavelet systems. The purpose of this talk is to discuss some classical topics concerning group representations and Fourier analysis, and understand some of their applications such as the extraction of musical score-like diagrams from digital music, or the modelling of some brain's neural processes related to motion perception. Recent results on dictionary learning from digital image datasets will also be presented, together with numerical simulations.

Thursday

9:30 - 10:30

Maximal regularity and Fourier multipliers

Marina Murillo Arcila, Universitat Politècnica de València
mamuar1@upv.es

The study of maximal regularity is understood as the analysis of the existence and uniqueness of solutions of differential equations. It is a fundamental tool to reduce a non-autonomous or non-linear problem through a fixed point argument to an autonomous or linear problem, respectively, or to apply an implicit function theorem. This study can be carried out using various techniques. One of them corresponds to the use of Fourier multipliers.

The objective of this talk will be first of all to make a brief introduction to the concepts of Fourier multipliers, their properties and other notions such as the R-boundedness of operators necessary to carry out the study of the maximal regularity of certain equations. Then, we will review some results concerning maximal regularity in Lebesgue spaces for both continuous and discrete time differential equations.

14:00- 15:00

Characters of finite groups

Carolina Vallejo Rodríguez, Universidad Carlos III de Madrid & ICMAT
carolina.vallejo@uc3.es, carolina.vallejo@icmat.es

Groups are the mathematical object formally describing our idea of symmetry. They appear naturally acting on vector spaces as groups of invertible matrices. Group Representation Theory is the branch of Mathematics that studies such actions. More specifically, Character Theory studies the trace maps associated to those actions. A fundamental question in the field is to understand how much information about a finite group G and its local subgroups can be extracted from the knowledge of the Character Theory of G. In this talk, I will report on recent advances in this topic.

Workshops

Wednesday, 15:00 - 16:30

How to talk and write mathematics

Marc Noy, Universitat Politècnica de Catalunya
marc.noy@upc.edu

Communication is a fundamental issue in the career of a mathematician or any scientist. In this lecture I will try to give useful advice to young researchers in order to improve their oral and written communication skills. Of course it takes time to become a good speaker and to learn how to write papers professionally, but I believe that there are some simple and useful rules that can help in the process.

Thursday, 11:00 - 12:30

IBM quantum computing workshop

Carmen Recio Valcarce, IBM
Carmen.Recio.Valcarce2@ibm.com

Quantum computers can tackle problems in entirely new ways leveraging entanglement, superposition, and interference, we will explain these concepts with different exercises. We will learn how to run experiments in a cloud-based IBM Quantum computer using the platform IBM Quantum Experience, and how to program with Qiskit, the open source framework for Quantum Computing. Finally, we will see an example of how to solve a real problem using a quantum computer.

Here is a list of references and important links:

- Qiskit: `https://qiskit.org`
- Qiskit textbook: `https://qiskit.org/textbook/preface.html`
- IBM Q Experience: `https://quantumexperience.ng.bluemix.net/qx/community`
- *Quantum Computation and Quantum Information*, Michael A. Nielsen & Isaac L. Chuang: `https://doi.org/10.1017/CBO9780511976667`

All people interested in Quantum Computing are welcome to attend. Please sign up at `https://quantum-computing.ibm.com`. A background in linear algebra and Python are recommended but not required.

Thursday, 17:00- 18:30

How to create a divulgative video about your research

Juan Miguel Ribera Puchades, Universidad de La Rioja
juan-miguel.ribera@unirioja.es

In a technological world where it is very easy to access devices that allow the reproduction of audiovisual content, alternatives to the generation of scientific documents, beyond plain text, should be considered. One of these alternatives is short divulgative videos. In this workshop we will present both the main characteristics that are recommended for divulgative mathematics videos and tools that will ease their creation. In this way, we will present the details that must be taken into account for the planning, recording, editing and distribution of these videos together with tools for self-evaluation of the content created. All this so that young researchers can Bringing Young Mathematicians Videos Together in the future.

COVID-19 round table

On Tuesday, starting at 17:00, we will host a round table discussion about the role of mathematics in managing the crisis of COVID-19. The discussion will be moderated by Pablo Jáuregui Narváez, Head of Scientific and Environmental Communication (FBBVA), and led by the following renowned individuals:

Santi García Cremades

Santi García Cremades (Universidad Miguel Hernández de Elche, UMH) is a mathematician and science populariser. He is a member of the Centro de Investigación Operativa of the UMH. He is the author of the book *Un número perfecto* (Oberon) and of the YouTube channel *Raíz de Pi*. On TV, he has been a collaborator and reporter for *Órbita Laika* and *La Aventura del Saber* (La 2 TVE), and has taken part in *Late Motiv* (#0), *Liarla Pardo*, the news bulletin of Antena 3, *Espejo Público*, *La Mañana* (TVE) and La 7 TV, especially during the pandemic, with data about COVID-19. On the radio, he directs and presents the program *Raíz de 5* (Radio 5 RNE, five seasons), collaborates in *Más de Uno* (Onda Cero, with Carlos Alsina) and, since 2018, in *Gente Despierta* (RNE, with Alfredo Menéndez), and he has collaborated in three seasons of *Las Mañanas de RNE*. He has created audiovisual formats such as Telecienciario (*El Mundo*) and Scenio Battle (Twitch), and has performed over 500 times in theatres, museums, high schools and bars, telling and singing the most fun side of science.

David Gómez Ullate

David Gómez Ullate is Distinguished Researcher at the Universidad de Cádiz since 2018, and Professor of Applied Mathematics on leave from the Universidad Complutense de Madrid. His research interests lie in mathematical physics, modelling of complex systems, and applying data science and machine learning to tackle real world problems. He enjoys facing new problems and cross fertilisation among disciplines. During the past years he has lead R+D projects with industrial partners on fraud detection, precision marketing, sustainable fishing and natural language processing on legal documents, as well as research projects funded by the Royal Society, the Spanish MINECO and the BBVA Foundation (Beca Leonardo). In relation to COVID-19, he has served in the panel *Acción matemática contra el Coronavirus* created by the Comité Español de Matemáticas.

Adeline Marcos

Adeline Marcos is a science journalist at the Spanish Scientific News Agency SINC, the first state public agency specialising in science in Spain. She is also a collaborator at the scientific news radio show *A Hombros de Gigantes* at the Spanish National Radio (RNE).

Clara Prats

Clara Prats holds a degree in Physics by the Universitat de Barcelona and a PhD in Applied Physics and Simulation in Sciences by the Universitat Politècnica de Catalunya (UPC). She is currently a lecturer at the UPC, researcher in the group of Computational Biology and Complex Systems, and responsible for computational models at the Center for Comparative Medicine and Bioimaging of the Germans Trias i Pujol Institute Research Center (IGTP). Her line of research focuses on the use of computer modeling for the study of infectious diseases, mainly tuberculosis, but also malaria, Chagas disease and, in recent months, COVID-19.

The discussion will focus on the following topics:

- What is the role of mathematics in the scientific efforts against COVID-19, and how have each of the speakers lived this experience from thee research or popularisation perspective?
- What hurdles and difficulties did you face when researching and spreading data about COVID-19?
- To what extent have political urgency and social pressure before the pandemic impeded the rigorous research and communication of the evolution of the COVID-19 pandemic?
- Have the “mathematics of the pandemic” been adequately divulged to society, or has there been some miscommunication?
- To what extent are “fake news” a problem when divulging the mathematics of the pandemic? How can we fight “infoxification”?
- What lessons can we learn from the experience and mistakes related to COVID-19, so that we may be more prepared to face future pandemics?

Contributed talks

Algebra

First session (Tuesday morning)

11:00 - 11:20

Fusion systems with few essential subgroups

Martin van Beek, University of Birmingham
MXV765@bham.ac.uk

Saturated fusion systems capture and abstract conjugacy in p-subgroups of finite groups and have recently found application in finite group theory, representation theory and algebraic topology. To each saturated fusion system $\mathcal{F}$, we can associate a certain collection of p-subgroups, its "essential subgroups", and morphisms which completely determine $\mathcal{F}$. In this talk, we describe a methodology to completely determine saturated fusion systems with a small number of essential subgroups.

11:20 - 11:40

On the isomorphism problem for even Artin groups

Rubén Blasco-García, Universidad de Zaragoza
rubenb@unizar.es

Artin groups is an interesting family of groups which can be defined associated to simple labeled graphs. Among them, I will focus on the subfamily of even Artin groups, in which every label is an even number.

Consider two Artin groups A_Γ, A_Ω with their standard presentation satisfying $A_\Gamma = A_\Omega$, is it true that their associated graphs must be equal (i.e. $\Gamma = \Omega$)? This is one of the most important open problems for Artin groups and it is known as the isomorphism problem.

This question is known to be true for right-angled Artin groups but false for general Artin groups. However, it is not known if it is true for even Artin groups. In this talk I will present some partial results regarding this question. This is a joint work with Luis Paris.

11:40 - 12:00

Standard Hausdorff spectrum of profinite $\mathbb{F}_p[[t]]$-analytic groups

Andoni Zozaya, Euskal Herriko Unibertsitatea
andoni.zozaya@ehu.eus

$\mathbb{F}_p[[t]]$-analytic groups are topological groups endowed with an analytic manifold structure over the pro-p domain $\mathbb{F}_p[[t]]$. When these groups are profinite, a natural Hausdorff dimension can be defined in them.

We will describe the Hausdorff spectrum, which is the collection of all the Hausdorff dimensions of closed subgroups, in those groups. In particular, we will show that the spectrum is full whenever the group is solvable and we will describe in further detail the spectrum of classical Chevalley groups.

This talk is based on a joint work with Jon González-Sánchez.

12:00 - 12:20

Axial algebras of Monster type $(2\eta, \eta)$ for orthogonal groups over $\mathbb{F}_2$

Yunxi Shi, University of Birmingham
yxs401@student.bham.ac.uk

Axial algebras are commutative non-associative algebras generated by special idempotents called axes satisfying a prescribed fusion law. This class was introduced by Hall, Rehren and Shpectorov who were motivated by applications in physics as well as in group theory. In this talk, we introduce the axial algebras of Monster type. The celebrated known examples are the Griess algebra and its subalgebras. By considering the classes of involutions of the isometry group of a non-degenerate orthogonal space over $\mathbb{F}_2$, we construct a new rich class of algebras of Monster type.

12:20 - 12:40

On the prime graph associated with class sizes of a finite group

Víctor Sotomayor, University Centre EDEM, Valencia
vsotomayor@edem.es

Let G be a finite group and $\mathrm{cs}(G)$ be the set of the sizes of the conjugacy classes of G. A well-established area of research within finite group theory is the study of the relations between the arithmetical properties of $\mathrm{cs}(G)$ and the structure of G. In the last decades, the *prime graph* built on $\mathrm{cs}(G)$ has played an important role. This graph, denoted by $\Delta(G)$, is defined as the (simple undirected) graph whose vertices are the prime divisors of the numbers in $\mathrm{cs}(G)$, and two distinct vertices p, q are adjacent if and only if pq divides some number in $\mathrm{cs}(G)$. The aim of this talk is to present some recent results that investigate the interplay between graph-theoretical features of $\Delta(G)$ and the structure of G itself.

This is a joint work with S. Dolfi, E. Pacifici, and L. Sanus.

12:40 - 13:00

p-origamis: strata, Veech groups and sums of Lyapunov exponents

Andrea Thevis, Universität des Saarlandes
thevis@math.uni-sb.de

In this talk, we study a certain class of translation surfaces called p-origamis. These surfaces arise as normal covers of the torus with p-groups as deck transformation group. We classify the types of singularities of p-origamis and show that these depend in most cases only on the isomorphism class of the deck transformation group. For this, we use the rich theory of p-groups.

Veech groups of p-origamis are finite index subgroups of $\mathrm{SL}(2,\mathbb{Z})$ and capture a lot of information about the respective surfaces. We describe first results regarding Veech groups of p-origamis. Using these results, we compute the sum of Lyapunov exponents for certain example series of p-origamis.

This is partially joint work with Johannes Flake.

Second session (Tuesday afternoon)

15:00 - 15:20

Different approaches for quadratic 2-step nilpotent Lie algebras

Jorge Roldán-López, Universidad de La Rioja
jorge.roldanl@unrioja.es

A quadratic Lie algebra is a Lie algebra equipped with a non-degenerate symmetric invariant bilinear form. Among all these algebras, we are going to focus on the nilpotent ones whose nilpotency index is two and, particularly, on those which are reduced. There exist different techniques to construct these algebras. Double extensions and T^*-extensions are recursive methods that allow us to start from smaller dimensions and grow up (Medina and Revoy, 1985; Bordemann, 1997). Fixing an appropriate basis and using its definition gives us another two approaches to these algebras (Benito, de-la-Concepción, Laliena, Roldán and Sesma, 2017, 2018). And finally, we have that their classification is equivalent to classifying alternating trilinear forms (Noui and Revoy, 1997). In this talk we are going to focus on the basis and trilinear approaches, showing how we can change between them and how we can construct and classify these algebras when dimensions are low.

This is joint work with Pilar Benito.

15:20 - 15:40

On the bracket of integrable derivations

María de la Paz Tirado Hernández, Universidad de Sevilla
mtirado@us.es

Let k be a commutative ring and A a commutative k-algebra. A k-linear derivation $\delta\colon A \to A$ is said to be integrable if it extends up to a Hasse-Schmidt derivation of A over k of infinity length. We prove that the bracket of two integrable derivations is also integrable and we conclude that module of integrable derivations is a Lie-Rinehart algebra over A/k.

This is a joint work with Luis Narváez Macarro.

15:40 - 16:00

Higher derivation with Lie structure of associative rings

Mehsin Jabel Atteya, University of Leicester and Al-Mustansiriyah University
mjaas2@leicester.ac.uk

The main purpose of this paper is to study and investigate some properties about a higher derivation $D = (d_i \neq 0)_{i\in\mathbb{N}}$ of a Lie structure U into an associative ring R such that R admits to $D = (d_i \neq 0)_{i\in\mathbb{N}}$ satisfying certain relations of R. In fact, this article is divided into two sections. In the first section, we emphasize on an associative ring R with the center $Z(R)$, $D = (d_i \neq 0)_{i\in\mathbb{N}}$ is a higher derivation of R and U is a Lie ideal of R. We deduce that R has either a weak zero-divisor or a weakly semiprime ideal.

In the second section, we study further results on a weak zero-divisors of an associative ring R where a ring R satisfies certain identities. Here $\mathbb{N}$ is the set of positive integers.

Indeed, these results with their applications will take part to answer of a common question is that why should derivations be studied. From our knowledge, derivations of rings were used to help us gain a better understanding of the structure of rings and their properties. Also, derivations can help to relate a ring to the set of matrices with entries in a ring. Derivations are useful in other fields. For example, they play an important role in the calculation of matrix eigenvalues, which finds applications to several areas like business, engineering and quantum physics.

16:00 - 16:20

On the universal central extension of superelliptic affine Lie algebras

Felipe Albino dos Santos, Universidade de São Paulo
falbinosantos@gmail.com

We describe explicitly in terms of generators and relations the universal central extension of infinite-dimensional superelliptic affine Lie algebras $\mathfrak{g} \otimes R$ with a finite-dimensional simple Lie algebra $\mathfrak{g}$ and the coordinate ring $R = \mathbb{C}[t, t^{-1}, u]$, where $u^m = p(t)$ and $p(t)$ is a polynomial with distinct roots.

16:20 - 16:40

How to catch a non-set

Greta Coraglia, Università di Genova
coraglia@dima.unige.it

We usually say that an element either belongs to a set, or it doesn't. What if an element was instead a member of a set to a *certain* degree, with a *certain* probability, or in a *certain* period in time, for example? And what if we brought this further, to the point that two elements of the same set were equal to *some* extent, without being the same nor entirely different? This is in fact pretty common in the mathematical experience: we are used to things being different, but acting the same way in *some* context. If we'd accept to live in such a fuzzy world, we would have many more sets than we are used to. But if they walk like a set, and they talk like a set, they are sets all the same.

We know that in this "universe" (a category, here) there is a smaller one (a subcategory of the first) that catches exactly the sets of (intuitionistic) Zermelo-Fraenkel set theory, but also that this is actually smaller than the first in most cases.

On the other hand, there have been suggestions that a universe as big as the first category could model a different set theory, BIST, which has the interesting feature of having a predicate *detecting* sets. This is exciting because if we managed to fit it onto our universe, we could see if there are other sets there, and what things that come from sets —but are not sets!— look like.

16:40 - 17:00

Extending Turing reducibility and incomparable Turing degree, ideas to PACi learning model

Gihanee Senadheera, Southern Illinois University
gihanee.s@siu.edu

The Probably Approximately Correct (PAC) learning is one of the machine learning models. It was introduced by Leslie Valiant in 1984. There are many examples that are PAC learnable. To determine whether a given concept class is learnable, PAC reducibility is introduced. This definition integrates the complexity features to it, so PACi reducibility refers to the definition independent of size and computation time. This reducibility in PAC learning resembles the reducibility in Turing computability. The term PACi degree means the set of equivalence class of a PACi concept class. Similar to Turing degrees could there be a minimum degree in PACi reducibility? and could there be PACi degrees that are comparable? The focus of this abstract was inspired by the Post Problem and its solution. In 1957 Friedberg and Muchnik independently solved this by constructing computably enumerable sets A and B of incomparable degrees using the priority construction method. We adapt this idea to PACi reducibility and check whether there exist incomparable PACi degrees. We have constructed the effective concept class C_0 and C_1 using priority construction method such that C_0 is not reducible to C_1 and also C_1 is not reducible to C_0. In future, we could incorporate the size and time complexity to this reducibility and show that there exist PAC incomparable degrees.

Third session (Wednesday morning)

11:00 - 11:20

Gradings on a class of structurable algebras related to an Hermitian form

Alberto Daza Garcia, Universidad de Zaragoza
albertodg@unizar.es

Structurable algebras are used for studying Lie algebras via a modified TKK construction. In this talk we will first show one relationship between a class of structurable algebras related to an hermitian form and some kind of associative algebras with involution, and then, we will use this relation to give a classification of the gradings on this class of structurable algebras.

11:20 - 11:40

Operator-algebraic elements in prime rings

Jose Brox, Universidade de Coimbra
josebrox@mat.uc.pt

Let A be a prime ring with extended centroid $\mathcal{C}$. An element $a \in A$ is *nilpotent* if there is $n \in \mathbb{N}$ such that $a^n = 0$. Analogously, considering the Lie ring A^- with bracket product $[x, y] := xy - yx$ and $\mathrm{ad}\colon A \to A$ operator $\mathrm{ad}_x y := [x, y]$, we say that an element $a \in A$ is *ad-nilpotent* if there is $n \in \mathbb{N}$ such that $\mathrm{ad}_a^n = 0$ (as a map). For example, $\mathrm{ad}_a^1 = 0$ if and only if $[a, A] = 0$, i.e., iff $a \in Z(A)$ is *central*, and $\mathrm{ad}_a^2 = 0$ if and only if $a^2x - 2axa + xa^2 = 0$ for all $x \in A$. By a theorem of Martindale and Miers, an element is ad-nilpotent if and only if it is the sum of a nilpotent and a central element, so it is algebraic with minimal polynomial $(X - \lambda)^m \in \mathcal{C}[X]$ for some $\lambda \in \mathcal{C}$ and $m \in \mathbb{N}$. More in general, for $a \in A$ let L_a, R_a denote the left and right multiplication operators respectively (i.e., $L_a x := ax, R_a x := xa$) and from any fixed polynomial in 2 variables $f \in \mathcal{C}[X, Y]$ define the operator $f_a := f(L_a, R_a)$ for each $a \in A$. For example, if $f(X, Y) = X^2 - 2XY + Y^2$ then $f_a = L_a^2 - 2L_aR_a + R_a^2$ and $f_a(x) = a^2x - 2axa + xa^2 = \mathrm{ad}_a^2(x)$. We say that the element $a \in A$ is *f-algebraic* if $f_a = 0$ as a map. Generalizing Martindale and Miers theorem to its fullest, we show that any f-algebraic element is algebraic for any f and find, for a given f, the possible minimal polynomials that the f-algebraic elements can present. To do so we rewrite the problem as a question in ideals of polynomial rings in two variables, and then apply Gröbner bases at an elementary level, partial Hasse derivatives, and a multiset form of Alon's combinatorial nullstellensatz.

Algebraic and complex geometry

First session (Tuesday morning)

11:00 - 11:20

On the geometry and the topology of parametric curves

Christina Katsamaki, INRIA Paris, Sorbonne Université
christina.katsamaki@inria.fr

This is joint work with Fabrice Rouillier, Elias Tsigaridas and Zafeirakis Zafeirakopoulos.

We consider the problem of computing the topology and describing the geometry of a parametric curve in $\mathbb{R}^n$. We present an algorithm, PTOPO, that constructs an abstract graph that is isotopic to the curve in the embedding space. Our method exploits the benefits of the parametric representation and does not resort to implicitization.

Most importantly, we perform all computations in the parameter space and not in the implicit space. When the parametrization involves polynomials of degree at most d and maximum bitsize of coefficients τ, then the worst case bit complexity of PTOPO is $\widetilde{\mathcal{O}}_B(nd^6 + nd^5\tau + d^4(n^2 + n\tau) + d^3(n^2\tau + n^3) + n^3d^2\tau)$. This bound matches the current record bound $\widetilde{\mathcal{O}}_B(d^6 + d^5\tau)$ for the problem of computing the topology of a planar algebraic curve given in implicit form. For planar and space curves, if $N = \max\{d, \tau\}$, the complexity of PTOPO becomes $\widetilde{\mathcal{O}}_B(N^6)$, which improves the state-of-the-art result, due to Alcázar and Díaz-Toca [CAGD'10], by a factor of N^{10}. However, visualizing the curve on top of the abstract graph construction, increases the bound to $\widetilde{\mathcal{O}}_B(N^7)$. We have implemented PTOPO in MAPLE for the case of planar curves. Our experiments illustrate its practical nature.

11:20 - 11:40

Affine equivalences of trigonometric curves

Emily Quintero, Universidad de Alcalá
emily.quintero@edu.uah.es

We provide an efficient algorithm to detect whether two given trigonometric curves, i.e. two parametrized curves whose components are truncated Fourier series, in any dimension, are affinely equivalent, i.e., whether there exists an affine mapping transforming one of the curves onto the other. If the coefficients of the parametrizations are known exactly (the exact case), the algorithm boils down to univariate gcd computation, so it is efficient and fast. If the coefficients of the parametrizations are known with finite precision, e.g. floating point numbers (the approximate case), the univariate gcd computation is replaced by the computation of approximate gcds. Our experiments show that the method works well, even for high degrees.

11:40 - 12:00

Primary ideals and their differential equations

Roser Homs, MiS MPI Leipzig
homspons@mis.mpg.de

An ideal in a polynomial ring encodes a system of linear partial differential equations with constant coefficients. Primary decomposition organizes the solutions to the PDE. This work develops a novel structure theory for primary ideals in a polynomial ring. We characterize primary ideals in terms of PDE, punctual Hilbert schemes, relative Weyl algebras, and the join construction. Solving the PDE described by a primary ideal amounts to computing Noetherian operators in the sense of Ehrenpreis and Palamodov. We develop new algorithms for this task, and we present efficient implementations. This is a joint project with Yairon Cid-Ruiz and Bernd Sturmfels.

12:00 - 12:20

Secure communications using group rings

María Dolores Gómez Olvera, Universidad de Almería
gomezolvera@ual.es

Key management is a central problem in information security. The development of quantum computation could make protocols we currently use insecure. In this work, we introduce a group key management protocol for secure group communications in a non-commutative setting. We show that the security of the initial key agreement is equivalent to the protocol given for just two communication parties, i.e. there is no information leakage as the number of users grows. Moreover we show that further rekeying messages provide forward and backward security, that means that no former or future user in a communication group can get information on previous or new future keys.

This is joint work with J. A. López-Ramos and B. Torrecillas.

12:20 - 12:40

Polarization, depolarization and support posets applied to system reliability

Patricia Pascual-Ortigosa, Universidad de La Rioja
papasco@unirioja.es

In this talk we present the inverse algebraic operations *polarization* and *depolarization*, which allow us to transform a monomial ideal into a squarefree monomial ideal, and viceversa. To work with both operations, we are going to use an algebraic tool called *support poset of a monomial ideal* which helps us to find all the monomial ideals that have the same squarefree monomial ideal as polarization.

In the first part of the talk, we show how polarization and depolarization work, giving some examples and providing theoretical results related to both operations.

After that, we present the support poset of a monomial ideal, showing some properties of the ideals depending on the shape of its support poset.

Finally, we apply polarization, depolarization and support posets to the study of reliability systems.

Second session (Tuesday afternoon)

15:00 - 15:20

Character varieties of torus knots

Ángel González-Prieto, Universidad Politécnica de Madrid
angel.gonzalez.prieto@upm.es

Attached to any topological space X, we find its character variety. This is a variety parametrizing isomorphism classes of representations $\pi_1(X) \to G$ of the fundamental group of X into an algebraic group G. When X is a compact orientable surface, these character varieties play a crucial role in the so-called non-abelian Hodge correspondence, that shows that the character variety is diffeomorphic to the moduli spaces of flat connections and of Higgs bundles on X.

They are also particularly useful in classical knot theory, since they provide very subtle invariants of knot $K \subseteq \mathbb{R}^3$ by taking $X = \mathbb{R}^3 - K$. However, even in the simplest cases, a full understanding of these character varieties is an open problem. In this talk, we will focus on the case in which K is a torus knot. For it, we will explain how the computation the motif of the $\mathrm{SL}_n(\mathbb{C})$-character variety can be reduced to representation theory of finite groups plus a combinatorial problem. This approach, combined with the aid of a computer algebra system, gives rise to new astonishing closed formulas for $\mathrm{SL}_4(\mathbb{C})$-character varieties.

15:20 - 15:40

Monodromy of germs of analytic functions without fixed points

Roberto Giménez Conejero, Universitat de València
roberto.gimenez@uv.es

In this joint work with J. J. Nuño-Ballesteros and Lê Dũng Tráng we prove that, given $f\colon (X,x) \to (\mathbb{C},0)$ such that $f \in \mathfrak{m}^2 O_{X,x}$, there is a geometric local monodromy of f without fixed points and we give an application of this fact in a broad context.

A geometric monodromy appears every time we have a local trivial fibration over S^1, say $f\colon U \to S^1$. Broadly speaking, it is a map of a fiber $F = f^{-1}(x_0)$ onto itself that is defined by taking F to give a *loop around* S^1.This is the situation of $f\colon (X,x) \to (\mathbb{C},0)$ such that $f \in \mathfrak{m}^2 O_{X,x}$ and the fibration induced by taking a small enough circumference around 0, in this case is called local geometric monodromy. Finally, we use it to prove that, in a broad context, the critical points of a family of functions from a family of complex analytic sets cannot split along the family.

This generalizes two theorems of the second coauthor, one stated for $\mathbb{C}^n$ instead of X and other for hypersurfaces; and gives an alternative proof of a result of A'Campo, that the Lefschetz number is zero.

15:40 - 16:00

Segre invariant and rank 2 vector bundles on surfaces

Leonardo Roa Leguizamón, Universidad Michoacana de San Nicolás de Hidalgo
leonardo.roa@cimat.mx

In this talk, we define the Segre invariant for rank 2 vector bundles on surfaces and give a stratification of the moduli space $M_{X,H}(2;c_1,c_2)$ of $H-$stable vector bundles of rank 2 and fixed Chern classes c_1 and c_2 on the surface X. For a vector bundle E of rank 2 on X, the Segre invariant is defined as the minimum of the differences between the slope of E and the slope of all line subbundles of E. This invariant defines a semicontinuous function on the families of vector bundles on X. Thus, the Segre invariant gives a stratification of the moduli space $M_{X,H}(2;c_1,c_2)$ into locally closed subvarieties $M_{X,H}(2;c_1,c_2;s)$. For $X = \mathbb{P}^2$ or X a Hirzebruch surface We study the stratification, determine conditions under which the different strata are non-empty and compute their dimensions. As a consequence of this stratification, we give results related to the Brill-Noether problem.

For $X = \mathbb{P}^2$ this is joint work with H. Torres-Lopez and A. Zamora.

16:00 - 16:20

Stacky curves in characteristic *p*

Andrew Kobin, University of California
akobin@ucsc.edu

As stacks continue to become an essential part of a modern algebraic geometer's toolbox, researchers look to their local structure as a guide to their nature. Over the complex numbers, this local structure is called a complex orbifold, or 'orbit space of a manifold' under a cyclic group action. In this talk, I will survey the classification of stacky curves in characteristic 0 and introduce a new construction, called an Artin–Schreier root stack, which allows for similar classification results in characteristic p.

16:20 - 16:40

Universal spectral covers and the Hitchin system

Guillermo Gallego, Universidad Complutense de Madrid
guigalle@ucm.es

We study spectral data for pairs (E,φ), where $E \to X$ is a holomorphic vector bundle over a compact Riemann surface X and $\varphi\colon E \to E \otimes V$ is an endomorphism twisted by another holomorphic vector bundle $V \to X$, satisfying an *integrability condition* $\varphi \wedge \varphi = 0$. When $V = K_X$ is the canonical bundle of X, these pairs (E,φ) are *Higgs bundles*, which play a fundamental role in nonabelian Hodge theory. The study of spectral data for this last situation was made by Hitchin in 1987 and by Beauville, Narasimhan and Ramanan two years later for the more general case where $V = L$ is a line bundle.

Very recently, Chen and Ngô have explored spectral data for Higgs bundles over higher dimensional algebraic varieties X, defined by Simspson as pairs (E, φ), with $E \to X$ an algebraic vector bundle over X and $\varphi\colon E \to E \otimes \Omega^1_X$ an endomorphism twisted by the algebraic cotangent bundle Ω^1_X of X, satisfying again an *integrability condition* $\varphi \wedge \varphi = 0$. Clearly, this situation shares a lot of similarities with our problem.

In this talk we review the *universal spectral cover*, the *Higgs stack*, the *universal Hitchin map*, and the *spectral correspondence* given by Chen and Ngô. We conclude by constructing *flat spectral curves* for our situation, whose existence guarantees that the generic fibres of the Hitchin morphism are not empty.

16:40 - 17:00

$N = 2$ superconformal vertex algebras from Killing spinors: an example of $(0, 2)$-mirror symmetry

Andoni De Arriba De La Hera, ICMAT - Universidad Complutense de Madrid
andoni.dearriba@icmat.es

A vertex algebra is an algebraic structure introduced by Richard Borcherds to prove the monstrous moonshine conjecture, which shows a connection between the monster group and the modular forms. They have always played an outstanding role in string and conformal field theory. However, in the recent years, vertex algebras have had a strong impact on algebraic topology and geometry. Indeed, for example, they can be used to construct invariants, such as the elliptic genus, that requires an important sheaf of vertex algebras called chiral De Rham complex.

The aim of this talk will be the construction of an embedding from the $N = 2$ superconformal vertex algebra, which is one of the canonical examples of SUSY vertex algebra motivated by conformal field theory, into the so-called superaffinization of a given Lie quadratic algebra $(\mathfrak{g}, (\cdot|\cdot))$ when it is satisfied the next condition: we have a solution for the Killing spinor equations in $(\mathfrak{g}, (\cdot|\cdot))$. The first step will be to introduce the Killing spinors in $(\mathfrak{g}, (\cdot|\cdot))$ and some basic background on the SUSY formalism for the vertex algebras. After that, I will be ready to present an example of Lie quadratic algebra satisfying such condition, which comes from an homogeneous Hopf surface. At the end, it will be shown that this is an example of $(0, 2)$-mirror symmetry.

Third session (Thursday afternoon)

15:00 - 15:20

The shapes of level curves of real polynomials near strict local minima

Miruna-Stefana Sorea, MPI MiS Leipzig
miruna.stefana.sorea2019@gmail.com

We consider a real bivariate polynomial function vanishing at the origin and exhibiting a strict local minimum at this point. We work in a neighbourhood of the origin in which the non-zero level curves of this function are smooth Jordan curves. Whenever the origin is a Morse critical

point, the sufficiently small levels become boundaries of convex disks. Otherwise, these level curves may fail to be convex. The aim of this talk is two-fold. Firstly, to study a combinatorial object measuring this non-convexity; it is a planar rooted tree. And secondly, we want to characterise all possible topological types of these objects. To this end, we construct a family of polynomial functions with non-Morse strict local minima realising a large class of such trees.

15:20 - 15:40

Real hyperbolic morphisms

Matilde Manzaroli, Universitetet i Oslo
manzarom@math.uio.no

Let X be a non-singular real algebraic variety of dimension n. We say that a real morphism f from X to $\mathbb{P}^n$ is *separating* if the preimage via f of $\mathbb{P}^n(\mathbb{R})$ equals $X(\mathbb{R})$. Thanks to Ahlfors and Klein, the characterisation of curves admitting real separating morphisms is well konwn. Let C be a non-singular real algebraic curve. Then C admits a separating morphism if and only if C is *separating*, i.e., the real set of points $C(\mathbb{R})$ divides the complex set of points $C(\mathbb{C})$ of C in two halves. Separating curves have interesting properties. For example, looking at $C(\mathbb{R})$ and its position with respect to $C(\mathbb{C})$ gives us information about the number of connected components of $C(\mathbb{R})$ and viceversa. For $n > 1$, the existence of a separating morphism is no longer equivalent to the fact that $X(\mathbb{R})$ divides $X(\mathbb{C})$ in two halves. *Can we characterise n-varieties admitting separating morphisms?* Moreover, one may focus on particular separating morphisms, called *hyperbolic*, given as the composition of an embedding of X in some $\mathbb{P}^N$ and a projection into $\mathbb{P}^{\dim X}$. We give general criteria to classify separating and hyperbolic morphisms of n-dimensional varieties. In the case of surfaces, we characterise the separating morphisms of del Pezzo surfaces and determine which of such morphisms are hyperbolic.

This is a joint work with Mario Kummer and Cédric Le Texier.

15:40 - 16:00

Minimality of tensors of fixed multilinear rank

Khazhgali Kozhasov, Technische Universität Braunschweig
k.kozhasov@tu-braunschweig.de

Multilinear rank of a tensor is a generalization of the notion of the rank of a matrix (order two tensor). Tensors of fixed multilinear rank form a smooth submanifold M (open subvariety) of the Euclidean space of all tensors of a given format. We discover a new geometric property of M, its minimality in the sense of differential geometry, and discuss applications of our result to the linear programming over M.

Based on a joint work with A. Heaton and L. Venturello.

16:00 - 16:20

Betti numbers of random hypersurface arrangements

Abhiram Natarajan, University of Colorado-Boulder
abhiram.natarajan.57@gmail.com

We study the expected behavior of the Betti numbers of arrangements of the zeros of random (distributed according to the Kostlan distribution) polynomials in $\mathbb{R}P^n$. Using a random spectral sequence, we prove an asymptotically exact estimate on the expected number of connected components in the complement of s such hypersurfaces in $\mathbb{R}P^n$. We also investigate the same problem in the case where the hypersurfaces are defined by random quadratic polynomials. In this case, we establish a connection between the Betti numbers of such arrangements with the expected behavior of a certain model of a randomly defined geometric graph. While our general result implies that the average zeroth Betti number of the union of random hypersurface arrangements is bounded from above by a function that grows linearly in the number of polynomials in the arrangement, using the connection with random graphs, we show an upper bound on the expected zeroth Betti number of random quadrics arrangements that is sublinear in the number of polynomials in the arrangement. This bound is a consequence of a general result on the expected number of connected components in our random graph model which could be of independent interest.

Joint work with Saugata Basu and Antonio Lerario.

16:20 - 16:40

Galois/monodromy groups in 3D reconstruction

Timothy Duff, Georgia Tech
tduff3@gatech.edu

In computer vision, the study of minimal problems is critical for many 3D reconstruction tasks. Solving minimal problems comes down to solving systems of polynomial equations of a very particular structure. "Structure" can be understood in terms of the Galois/monodromy group of an associated branched cover. For classical problems such as homography estimation and five-point relative pose, efficient solutions exploit imprimitivity of the Galois groups; in these cases, the imprimitivity comes from the existence of certain rational deck transformations. In general, Galois groups can be computed with numerical homotopy continuation using a variety of software. I will highlight joint work with Viktor Korotynskiy, Tomas Pajdla, and Maggie Regan that studies an ever-expanding zoo of minimal problems and their Galois groups, with a view towards identifying new minimal problems that may be useful in practice.

Analysis and operator algebras

First session (Tuesday morning)

11:00 - 11:20

AT-algebras arising from zero-dimensional dynamical systems

Paul Herstedt, Ben Gurion University of the Negev
pherstedt@gmail.com

We introduce a type of dynamical system (called "fiberwise essentially minimal") where the space is a totally disconnected compact Hausdorff space such that the associated crossed product is guaranteed to be an $A\mathbb{T}$-algebra. This extends work done by Putnam and Putnam-Giordano-Skau in the early 90's, in which the dynamical systems were assumed to be essentially minimal (which means that each orbit closure contains a unique minimal set) and to have no periodic points. We will outline the idea behind this extension and give examples of related results that we soon hope to extend as well.

11:20 - 11:40

On the connection between Hardy kernels and reproducing kernels

Jesus Oliva-Maza, Universidad de Zaragoza
joliva@unizar.es

Hardy kernels are a useful tool to construct integral bounded operators. In this talk, we present the main results of our study on the range spaces of these operators. In particular, we are able to obtain the following: under certain conditions, these range spaces are reproducing kernel Hilbert spaces whose reproducing kernel is given by another Hardy kernel.

11:40 - 12:00

Topological reflexivity of the isometry groups of $C(Y)$-valued Lipschitz algebras

María de Gádor Cabrera Padilla, Universidad de Almería
m_gador@hotmail.com

Along the recent years, it has been investigated if bounded linear operators behaving at each point as surjective linear isometries defined between Lipschitz algebras are, in fact, surjective linear isometries. Jiménez-Vargas, Morales-Campoy, Villegas-Vallecillos and Oi proved that this is true in the case in which these maps are defined between the Banach algebra of complex-valued Lipschitz maps endowed with the sum norm. Furthermore, the last author showed that the same statement holds when we deal with isometries defined between the algebra of Lipschitz functions taking values in the space of continuous functions defined on a compact Hausdorff space. However, are these results still true when we consider bounded linear operators satisfying more general properties? We will answer affirmatively to this question when we cope with bounded linear operators whose evaluation at each point is the limit in the sum norm of a sequence of surjective linear isometries at the same point.

For this aim, we will make use of the descriptions of the surjective linear isometries defined between Lipschitz algebras due to Hatori and Oi and the spherical version of the Gleason-Kahane-Żelazko theorem given by Li, Peralta, Wang and Wang.

This is joint work with Antonio Jiménez-Vargas (Universidad de Almería, Spain).

12:00 - 12:20

The attack of axiomatics in $C(K)$-spaces

Alberto Salguero-Alarcón, Universidad de Extremadura
salgueroalarcon@unex.es

This talk focuses on a few problems about the structure of spaces of continuous functions posed by Marciszewski and Pol, Koszmider, and Cabello, Castillo, Kalton and Yost. We will consider the so-called Alexandroff-Urysohn compact spaces, which are generated by certain families of subsets of the natural numbers, and the Banach spaces $C(K)$ they produce. We will explore their surprising properties which, much to our despair, depend on whether one assumes the Continuum Hypothesis or Martin's Axiom. This shows that several apparently harmless questions about twisted sums of $C(K)$-spaces are undecidable within the usual axioms of set theory. Recall that a twisted sum of two Banach spaces Y and X is another space Z which has Y as a subspace so that Z/Y is isomorphic to X.

12:20 - 12:40

Hyperreflexivity of the space of module homomorphisms between non-commutative L^p-spaces

María Luisa C. Godoy, Universidad de Granada
mgodoy@ugr.es

Let $\mathcal{M}$ be a von Neumann algebra, and let $0 < p, q \leq \infty$. Then, the space $\mathrm{Hom}_{\mathcal{M}}(L^p(\mathcal{M}), L^q(\mathcal{M}))$ of all right $\mathcal{M}$-module homomorphisms from $L^p(\mathcal{M})$ to $L^q(\mathcal{M})$ is a reflexive subspace of the space of all continuous linear maps from $L^p(\mathcal{M})$ to $L^q(\mathcal{M})$. Furthermore, the space $\mathrm{Hom}_{\mathcal{M}}(L^p(\mathcal{M}), L^q(\mathcal{M}))$ is hyperreflexive in each of the following cases: (i) $1 \leq q < p \leq \infty$; (ii) $1 \leq p, q \leq \infty$ and $\mathcal{M}$ is injective, in which case the hyperreflexivity constant is at most 8.

Second session (Tuesday afternoon)

15:00 - 15:20

The property (d) in Banach lattices and the alcc operators

Vinícius Miranda, IME-USP-Brazil
vinicius.colferai.miranda@usp.br

In this talk, we will consider the property (d) in Banach lattices and its applications in the class of almost limited completely continuous operators (ab. alcc) between Banach lattices. It is known that if a Banach lattice is σ-Dedekind complete then it has property (d). We improve some results in that direction, which have been proved to σ-Dedekind complete Banach lattices. As a consequence, we study some interesting properties concerning alcc operators. For example, we give sufficient conditions so that if $0 \leq S \leq T$ and T is an alcc operator, then S is also an alcc operator.

This is a joint work with Mary Lilian Lourenço.

15:20 - 15:40

An $\mathcal{A}$-tight - $\mathcal{A}$-minimal dichotomy theorem for Banach spaces

Alejandra Cáceres Rigo, Universidade de São Paulo - IME
acaceres@ime.usp.br

As part of the program of classification of Banach spaces up to subspaces initiated by W. T. Gowers, V. Ferenczi and Ch. Rosendal proved a third dichotomy which states that every Banach space has a subspace that is either minimal or tight. In this work we define the notions of $\mathcal{A}$-minimality and $\mathcal{A}$-tightness over Banach spaces with Schauder basis, considering $\mathcal{A}$ an admissible property over sequences of vectors in a Banach space. We generalize the techniques used in the proof of the third dichotomy to show that given an admissible property $\mathcal{A}$, every Banach space contains a separable Banach space that is either $\mathcal{A}$-minimal or $\mathcal{A}$-tight. We prove that the third dichotomy and other dichotomies given by V. Ferenczi and Ch. Rosendal are obtained as corollaries.

This research is financially supported by the FAPESP.

15:40 - 16:00

Free Banach lattices

José David Rodríguez Abellán, Universidad de Murcia
josedavid.rodriguez@um.es

The concept of *free* object is well known, can be expressed in the general language of the theory of categories, and has been proved very useful in various areas in both analysis and algebra. However, in the context of Banach lattices, it has been recently introduced.

In this talk we study the free Banach lattices generated by a set, by a Banach space, and by a lattice, respectively. Roughly speaking, the free Banach lattice generated by one of the objects mentioned above is a Banach lattice that contains an isomorphic copy of the object which generates it. We describe them as spaces of functions and show some of their properties, focusing on chain conditions and projectivity.

16:00 - 16:20

Invariant subspaces for positive operators on Banach spaces with unconditional basis

F. Javier González-Doña, ICMAT - Universidad Complutense de Madrid
javier.gonzalez@icmat.es

Let X be a (real or complex) Banach space and let $T\colon X \to X$ be a linear, bounded operator. A closed subspace $M \subset X$ is an *invariant subspace* for T if $T(M) \subseteq M$. The *Invariant Subspace Problem* asks if every linear, bounded operator acting on a Banach space has a non-trivial, closed invariant subspace. Although there exist counterexamples in classical Banach spaces, the problem remains open for many classes of operators. In this talk we consider the class of positive operators acting on Banach lattices, and more precisely, the class of lattice homomorphisms acting on Banach lattices.

We will introduce these concepts and present a recent joint work with Eva A. Gallardo-Gutiérrez and Pedro Tradacete, in which we show that every lattice homomorphism acting on Banach lattices whose order is induced by an unconditional basis has a non-trivial, closed invariant subspace (moreover, a non-trivial, closed invariant ideal). Finally, we will discuss the sharpness of the aforementioned results.

16:20 - 16:40

Normal tilings of a Banach space and its ball

Miguel García Bravo, University of Jyväskylä
miguel.garciab@uam.es

We show some new results about tilings in Banach spaces. A tiling of a Banach space X is a covering by closed sets with non-empty interior so that they have pairwise disjoint interiors. If moreover the tiles have inner radii uniformly bounded from below, and outer radii uniformly bounded from above, we say that the tiling is normal.

The first one who considered this problem in infinite dimensions for the case of non-separable Banach spaces was Klee in 1981. For instance he proved that the space $\ell_1(\Gamma)$, where Γ is a set with cardinality the continuum, can be covered by disjoint closed unit balls, contradicting somehow our intuition. Another important result was due to Fonf, Pezzotta and Zanco in 1997. They showed that any normed space admits a tiling by bounded convex sets, with uniformly bounded inner radii. Even more recently, in 2010, Preiss constructed a convex normal tiling of the separable Hilbert space.

The final goal of this talk is to show that for Banach spaces with Schauder basis one can show that Preiss' result is still true with starshaped tiles instead of convex ones. Also, whenever X is uniformly convex we as well have convex normal tilings of the unit ball or in general of any convex body.

This was a joint work with professor Robert Deville.

16:40 - 17:00

A Hatori-Mólnar type theorem for JB*-algebras

María Cueto-Avellaneda, Universidad de Granada
emecueto@gmail.com

This poster aims to address the question of whether two unital JB*-algebras can be identified by the metric spaces determined by their sets of unitaries. More concretely, it is showed that the Banach spaces underlying two unital JB*-algebras are isometrically isomorphic if and only if their unitary sets are isometric. Let M and N be two unital JB*-algebras, and let $\mathcal{U}(M)$ and $\mathcal{U}(N)$ denote the sets of all unitaries in M and N, respectively. The last conclusion follows from a more general statement asserting that, under some extra conditions, for each surjective isometry $\Delta\colon \mathcal{U}(M) \to \mathcal{U}(N)$ there exists a surjective real linear isometry $\Psi\colon M \to N$ which coincides with Δ on the subset $e^{iM_{sa}}$. This is an extension of the Hatori–Molnár theorem to the setting of JB*-algebras, and the particular case of M and N being JBW*-algebras means a positive answer to the well-known *unitary Tingley's problem*. In order to make the results understandable, basic definitions in Jordan structures will be exhibited.

This is a joint work with Antonio M. Peralta.

Third session (Wednesday morning)

11:00 - 11:20

Entropy numbers and best approximations of the classes of periodic multivariate functions

Kateryna Pozharska, Institute of Mathematics of NAS of Ukraine
kate.shvai@gmail.com

We obtain the estimates for certain approximative characteristics of the classes of periodic multivariate functions that are connected with nonlinear approximation. The great interest nowadays in such approximations is mainly caused by advantages of nonlinear methods over a linear one in many situations.

Namely, we investigate the behaviour of the best orthogonal and M-term trigonometric approximations of the classes of functions with bounded generalized derivatives (the classes of Weyl – Nagy type). Further we get the estimates of entropy numbers for the classes of functions with certain restrictions on their modulus of continuity (the classes of Nikol'skyi – Besov type).

When comparing the obtained estimates with known results for the approximations of corresponding functional classes by step hyperbolic Fourier sums and by trigonometric polynomials with the "numbers" of harmonics from step hyperbolic crosses, one can observe an improvement of these estimates caused by the use of nonlinear methods.

The work was made under the supervision of Prof. Romanyuk (the Head of the Theory of functions department of IM NASU) and partially financially supported by the budget program "Support of the development of priority branches of scientific research in 2020" (KPKVK 6541230).

11:20 - 11:40

Associate spaces and logarithmic interpolation methods

Blanca F. Besoy, Universidad Politécnica de Madrid
blanca.fbesoy@upm.es

Banach function spaces (BFS) are a special type of Banach spaces consisting of measurable functions. Many well-known function spaces such as Lebesgue spaces L_p, Lorentz spaces $L_{p,q}$, Lorentz-Zygmund spaces $L_{(p,q,\mathbb{A})}$, Orlicz spaces L^{Φ}, among others, are BFS. If X is a BFS, its associate space X' is defined as

$$X' = \Big\{ \text{measurable } f : \sup_{g \in X} \Big\{ \int |fg| : \|g\|_X \leq 1 \Big\} < \infty \Big\}.$$

When we apply the real interpolation method $(\cdot,\cdot)_{\theta,q}$ to two BFS X_0 and X_1, the resulting space $(X_0, X_1)_{\theta,q}$ is also a BFS. It is well known that $(X_0, X_1)'_{\theta,q} = (X'_0, X'_1)_{\theta,q/(q-1)}$ if $1 \leq q \leq \infty$ and $(X_0, X_1)'_{\theta,q} = (X'_0, X'_1)_{\theta,\infty}$ if $0 < q < 1$.

Some extensions of the ideas of real interpolation have required to consider logarithmic perturbations $(\cdot,\cdot)_{\theta,q,\mathbb{A}}$. In this talk, we are going to discuss the associate formula for logarithmic methods. As an application, we compute the associate spaces of Lorentz-Zygmund spaces $L_{(p,q,\mathbb{A})}$.

This talk is based on joint work with F. Cobos and L. M. Fernández-Cabrera.

11:40 - 12:00

Numerical index of absolute symmetric norms on the plane

Alicia Quero, Universidad de Granada
aliciaquero@ugr.es

The numerical index of a Banach space is a constant relating the norm and the numerical radius of bounded linear operators on the space. The problem of computing the numerical index of the L_p-spaces has been latent since the beginning of the theory. The aim of this talk is to give a lower bound for the numerical index of two-dimensional real spaces with absolute and symmetric norm. As a major consequence, this allows us to compute the numerical index of the two-dimensional real L_p-space for $3/2 \leq p \leq 3$, which throws some light to the long-standing problem of calculating the numerical index of L_p-spaces.

This is joint work with Javier Merí.

12:00 - 12:20

On unique extension renormings

Christian Cobollo, Universitat Politècnica de València
chcogo@posgrado.upv.es

Renorming Theory is a branch of Functional Analysis that focuses on the possibility of changing the norm on a Banach space for an equivalent one, but with better properties. Sullivan (1970) and recently, Oja, Viil and Werner (2019) have found some theorems that allow improving a property related with the uniqueness of extensions of linear continuous functionals.

Following Phelps, we say that a linear subspace M has **property U** in X if every linear continuous functional $f\colon M \to \mathbb{R}$ has a unique Hahn-Banach extension $\tilde{f}\colon X \to \mathbb{R}$. According to Sullivan and Smith, we say that X is Hahn-Banach Smooth (**HBS**) if X has property U in X^{**}. A stronger property is when X is Totally Smooth (**TS**), i.e., every subspace of X has property U on X^{**}. The results of Sullivan and Oja, Viil and Werner show that if X is HBS, then under some topological conditions (separability and WCG, respectively), it can be renormed to have TS property. During this talk, we show an improvement on both: we prove that, indeed, a Banach space with a HBS norm can be renormed to have a TS norm, **without any extra hypothesis**. This is a joint work with A. J. Guirao and V. Montesinos.

12:20 - 12:40

Logarithmic asymptotic of multi-level Hermite-Padé polynomials

Luis Giraldo González Ricardo, Universidad Carlos III de Madrid
luisggon@math.uc3m.es

We study the logarithmic asymptotic of multiple orthogonal polynomials arising in a mixed type Hermite-Padé approximation problem associated with the rational perturbation of a Nikishin system of functions. The formulas obtained allow to give exact estimates of the rate of convergence of the corresponding Hermite-Padé approximants. This is joint work with G. López Lagomasino and S. Medina Peralta.

12:40 - 13:00

Local Bollobás type properties and diagonal operators

Óscar Roldán, Universitat de València
oscar.roldan@uv.es

We study properties related to the density of norm-attaining operators. To do so, we introduce the set $\mathcal{A}_{\|\cdot\|}(X,Y)$ of norm-one norm-attaining operators from X to Y such that given some $\varepsilon > 0$, there exists $\eta(\varepsilon, T)$, such that if $\|T(x)\| > 1-\eta$, then there is x_0 with $\|x_0 - x\| < \varepsilon$ and T attains its norm at x_0. These are, in a way, operators so that whenever they almost attain their norm at a point, they do attain it at a nearby point. The analogous set $\mathcal{A}_{\text{nu}}$ for the numerical radius is also introduced and studied. We will give examples of operators that belong to these sets, and in particular, we give a characterization of what diagonal operators belong to these sets for the classical sequence Banach spaces. The contents of this talk are based in a joint work with Sheldon Dantas and Mingu Jung.

Fourth session (Thursday afternoon)

15:00 - 15:20

Large sets without Fourier restriction theorems

Constantin Bilz, University of Birmingham
C.Bilz@pgr.bham.ac.uk

We construct a function that lies in $L^p(\mathbb{R}^d)$ for every $p > 1$ and whose Fourier transform has no Lebesgue points in a compact set $E \subseteq \mathbb{R}^d$ of full Hausdorff dimension. By the recent maximal restriction principle of Kovač it follows that the Fourier transform is unbounded from $L^p(\mathbb{R}^d)$ to $L^q(\mu)$ for any Borel measure μ with $\mu(E) > 0$ and any exponents $1 < p < q$. This complements results of Mockenhaupt, Mitsis, Bak–Seeger and others who showed that such Fourier restriction estimates hold under a decay condition on the Fourier transform of the measure.

15:20 - 15:40

Weak compactness in variable exponent spaces

Mauro Sanchiz Alonso, Universidad Complutense de Madrid
msanchiz@ucm.es

One of the richest topics in functional analysis is the study of compactness. For each Banach space, we are interested in characterizing the compact sets of that space, as well as the sets with weaker forms of compactness like weakly compact sets. My work area consists in variable exponent Lebesgue spaces $L^{p(\cdot)}$, which are an extension of the well known Lebesgue spaces L^p. Recently, the compact sets of $L^{p(\cdot)}$ were characterized, and now me and my PhD advisors (F. L. Hernández and C. Ruiz) have characterized the weakly compact subsets as well.

In this talk, I will give an overview on the L^p and Orlicz spaces and the theorems on weak compactness on those spaces from which we got based and inspired to get our theorems. Also, a brief draft on the proof of those weak compactness theorems on $L^{p(\cdot)}$ will be given, as well as some consequences of them on the structure of $L^{p(\cdot)}$ and of their weakly convergent sequences.

All this work is collected in a paper submitted to the Journal of Functional Analysis, which is currently in review status.

15:40 - 16:00

Additivity of the families of Darboux-like functions

Daniel L. Rodríguez-Vidanes, Universidad Complutense de Madrid
dl.rodriguez.vidanes@ucm.es

In 1875, Jean-Gaston Darboux studied the functions that satisfy the Intermediate Value Property (IVP). It is well known that every continuous function in the real line maps connected sets to connected sets, i.e., satisfies the IVP. However, the converse is not true in general, that is, the family of real functions that maps connected sets to connected sets (known as Darboux functions) contains strictly the family of continuous functions. By considering properties that continuous functions have but not the other way around, we obtain the families of functions known as *Darboux-like* functions. We will study the families of Darboux-like functions and analyze a cardinal invariant known as additivity applied to these families.

Joint work with K. C. Ciesielski, T. Natkaniec and J. B. Seoane-Sepúlveda to appear in Results in Mathematics.

16:00 - 16:20

Yano's extrapolation theorem

Laura Sánchez-Pascuala Dones, Universidad Complutense de Madrid
lsanch12@ucm.es

In the field of Fourier analysis, transformations T that satisfy the following requirements play an important role:

$$\|T(f)\|_{L^p[0,2\pi]} \leq A_p \|f\|_{L^p[0,2\pi]}, \qquad p > 1,$$
$$\|T(f)\|_{L^1[0,2\pi]} \leq A_k \int_0^{2\pi} |f(x)| \log^k(1 + f^2(x))dx + B_k,$$

where A_p, A_k and B_k are constans depending only on p, k and k, respectively. However, the above inequalities were usually proved independently until in 1951 Yano developed a technique which allows us to obtain the second from the first one when the operator is sublinear.

This technique, a pioneer in the field of extrapolation theory, still arouses interest today due to its various applications. Furthermore, it is a source of inspiration for other extrapolation techniques such as those later developed by the illustrious Jose Luis Rubio de Francia.

In fact, the timeliness of this type of technique is evident in my field of study, where I investigate the application of them to obtain similar results in the case of multisublinear operators.

16:20 - 16:40

Linear and algebraic structures of anti-M Weierstrass sequences

Pablo José Gerlach Mena, Universidad de Sevilla
gerlach@us.es

We all know the M-Weierstrass Criterion which guarantees the ab-solute and uniform convergence of a series of functions that is dominated by aconvergent series, though it is not complicated to find examples of series beingabsolute and uniformly convergent without fulfilling the hypothesis of the M-Weierstrass Criterion. In this talk we are going to focus our attention on thealgebraic genericity of the family of series that are a counterexample to the M-Weierstrass Criterion. Results in this talk are part of a joint work with M. C. Caldern-Moreno and J. A. Prado-Bassas.

16:40 - 17:00

What is sparse domination and why is it so plentiful?

Gianmarco Brocchi, University of Birmingham
g.brocchi@pgr.bham.ac.uk

Many operators in analysis are non-local, in the sense that a perturbation of the input near a point modifies the output everywhere; consider for example the operator that maps the initial data to the corresponding solution of the heat equation.

Sparse Domination consists in controlling such operators by a sum of positive, local averages. This allows to derive plenty of estimates, which are often optimal.

In this talk we will introduce this concept, and, if time permits, we will discuss the case of operators that are beyond Calderón–Zygmund theory.

Applied mathematics

First session (Wednesday morning)

11:00 - 11:20

A novel normalized B-spline basis for univariate C^2 quartic super-spline spaces and applications

Salah Eddargani, Universidad de Granada and Université Hassan-1er
s.eddargani@gmail.com

Through a finite element approach, a normalized B-spline basis for a space of composite C^2 quartic splines is constructed. The splines are defined over an arbitrary partition of a compact interval, which is refined by adding a split point in each sub-interval. The basis functions are non-negative, have local supports, and form a convex partition of unity.

Then, we discuss a local Hermite interpolation scheme for C^2 quartic super-splines represented in the normalized B-spline basis. A general interpolation problem that uses values at the initial points of the partition and also at the split points is addressed.

11:20 - 11:40

Structure exploitation for PDE constrained nonsmooth optimization

Olga Weiß, Humboldt-Universität zu Berlin
olga.weiss@hu-berlin.de

We present an algorithm for the efficient solution of nonsmooth operator equations in reflexive Banach spaces where all non-differentiablilities are assumed to be given by Lipschitz-continuous operators such as abs(), min() and max().

These kinds of optimization problems arise in many applications and their efficient as well as robust solution requires numerical simulations combined with specific optimization algorithms.

Therefore, we formally define a new concept for solving nonsmooth operator equations such as nonsmooth optimal control problems constrained by PDEs where standard optimal control techniques for obtaining first-order optimal points cannot be applied.

The special feature of the presented optimization algorithm is the explicit exploitation of the nonsmooth structure.

11:40 - 12:00

Spectral estimates for saddle point matrices arising in numerical weather prediction

Ieva Daužickaitė, University of Reading
i.dauzickaite@pgr.reading.ac.uk

Data assimilation estimates the state of a dynamical system by combining a previous estimate of the state and observations of the system. It is used to determine initial conditions in numerical weather prediction, where the state can have 10^9 variables and 10^7 observations have to be assimilated.

We consider the weak constraint four-dimensional variational (4D-Var) data assimilation method. The state of the system is approximated using an inexact Gauss-Newton method, in which a series of linearized quadratic cost functions are minimized.

We consider the large sparse symmetric linear systems of equations that arise in the minimisation of the quadratic cost functions. These can be written as saddle point systems with a 3×3 block structure but block eliminations can be performed to reduce them to saddle point systems with a 2×2 block structure, or further to symmetric positive definite systems. In this talk, we analyse how sensitive the spectra of these matrices are to the number of observations of the underlying dynamical system. We also obtain bounds on the eigenvalues of the matrices. Numerical experiments are used to confirm the theoretical analysis and bounds.

This is joint work with Amos S. Lawless, Jennifer A. Scott, and Peter Jan van Leeuwen.

12:00 - 12:20

Accurate computations with totally positive matrices

Héctor Orera, Universidad de Zaragoza
hectororera@unizar.es

A matrix is totally positive if all its minors are nonnegative. Nonsingular totally positive matrices can be written as a product of bidiagonal matrices. This factorization is called bidiagonal decomposition and it can be used as a natural parameterization to perform many algebraic computations with these matrices to high relative accuracy. In fact, if we know the bidiagonal decomposition of a nonsingular totally positive matrix with high relative accuracy, then we can compute all its eigenvalues, all its singular values or its inverse with high relative accuracy. In this talk, we show some new subclasses of totally positive matrices for which the bidiagonal decomposition, and hence, the mentioned algebraic problems, can be computed with high relative accuracy.

12:20 - 12:40

Compositions of pseudo-symmetric integrators with complex coefficients for the numerical integration of differential equations

Alejandro Escorihuela-Tomàs, Universitat Jaume I
alejandro.escorihuela@uji.es

In this talk we will review a new class of integrators obtained by double jump compositions of a basic scheme with complex coefficients and projection on the real axis. We will show in particular that the new methods are time-symmetric and symplectic up to high orders if one uses a time-symmetric and symplectic basic integrator. This is a joint work with F. Casas (Castelló), P. Chartier (Rennes) and Y. Zhang (Wuhan).

Second session (Thursday afternoon)

15:00 - 15:20

Predicting the effect of hyperpressure on the displacement of the basilar membrene in active cochlea

Fatima-Ezzahra Aboulkhouatem, Université Hassan II de Casablanca
fatiaboulkhouatem@gmail.com

The cochlea is the main organ of auditory perception. It works continuously and makes it possible to feel the sound environment. In fact, the sound travels a chain of transmission and goes through different states before being converted by the brain into some interpretable neural signals. Because of the complexity of the hearing system, the study of the behaviour of this system by mathematicians is very relevant and it allows to enrich and develop the biological discoveries. Mathematical models of the cochlea are used to predict certain behaviours and suggest new physiological experiments. The main objective of this paper is to study the behaviour of the active cochlea in the case of a disturbance in its physical parameters. So, we developed a mathematical model of the cochlea in order to obtain the displacement of the Basilar Membrane of each position. Then, we disturbed the pressure and we shown the changes decuced on cochlear behavior in the case of hyperpressure. At the end of this work, we presented numerical simulations that allow us to compare the maximum displacement of the Basilar Membrane in the normal and abnormal cases to validate the hypotheses proposed.

15:20 - 15:40

The influence of an increase of basilar membrane stiffness on the cochlear partition model

Fatiha Kouilily, Université Hassan II de Casablanca
kouililyfatiha@gmail.com

In this study, we have studied the effect of basilar membrane (BM) stiffness on the displacement of cochlear partition model by using finite difference method. Mathematical results showed that an increase of the BM stiffness reduce the maximum amplitude displacement of the cochlear partition. These findings contribute to understand that the loss of hearing at low frequencies may be the result of altered cochlear micromechanics.

15:40 - 16:00

Diffusion tensor imaging (DTI) based drug diffusion model in a solid tumor

Erdi Kara, Texas Tech University
erdi.kara@ttu.edu

In this work, we study the effect of drug distribution on tumor cell death when the drug is internally injected in the tumorous tissue. We derive a full 3-dimensional inhomogeneous – anisotropic diffusion model. To capture the anisotropic nature of the diffusion process in

the model, we use an MRI data of a 35-year old patient diagnosed with Glioblastoma multiform(GBM) which is the most common and most aggressive primary brain tumor. After preprocessing the data with a medical image processing software, we employ finite element method in MPI-based parallel setting to numerically simulate the full model and produce dose-response curves. We then illustrate the apoptosis (cell death) fractions in the tumor region over the course of simulation and proposed several ways to improve the drug efficacy. Our model also allows us to visually examine the toxicity. Since the model is built directly on the top of a patient-specific data, we hope that this study will contribute to the individualized cancer treatment efforts from a computational bio-mechanics viewpoint.

16:00 - 16:20

Application of the high order accuracy method to solve viscous Burgers' equation for weather forecast model

Shokoufeh Ghezeljeh, Iran University of Science and Technology
shokofeh.ghezeljeh@gmail.com

In this paper, we considered high order finite difference scheme for solving viscous burgers' equation which using in weather forecast model. The proposed method is a combination of high order finite difference method and alternating direction implicit (ADI) method. At first, the space variable is discretized by a fourth order finite difference scheme. Then, we use ADI method for discretization the time variable. This method is second order in time and fourth order accurate in space and involves three grid points of a single compact cell. The numerical results show the efficiency of the method in various viscosity coefficient.

16:20 - 16:40

Energy-stable numerical schemes for a diffuse-interface tumor-growth model

Daniel Acosta-Soba, Universidad de Cádiz
daniel.acostsoba@alum.uca.es

We introduce two new numerical schemes for a tumor-growth model based on the Cahn-Hilliard phase-field equation for the tumor variable and a reaction-diffusion equation for the nutrient one, coupled by reaction and cross-diffusion terms. Both schemes have good properties: they are linear, mass conserving and energy-stable. One of the schemes uses a convex splitting time semidiscretization and a Finite Element (FEM) space semidiscretization whereas the other combines an Energy Quadratization (EQ) time semidiscretization with a discontinuous Galerkin (DG) space semidiscretization. Furthermore, we present several numerical tests which meet the theoretical results and show some modeling possibilities of the studied equations. This is joint work with Francisco Guillén-González (Universidad de Sevilla) and J. Rafael Rodríguez-Galván (Universidad de Cádiz).

16:40 - 17:00

Optimal configuration of boundary conditions for a piezoelectric problem with OED

Veronika Schulze, Humboldt-Universität zu Berlin
veronika.schulze@hu-berlin.de

Nowadays, the importance and use of smart materials is growing, resulting in the application of piezoelectricity, which makes accurate knowledge of piezoelectric material properties indispensable. The behaviour of a piezoelectric ceramic disc with electrodes on top and bottom can be mathematical described by PDEs with initial and boundary conditions. The latter defines mainly the electrical excitation and grounding of the piezoceramic. In addition it has significant influence on the results of the forward problem, such as the mechanically displacement and the electrical potential.

The quantity with the most impact in piezoelectric development here is the electrical impedance, which can best be used to identify the material parameters. To improve the experimental setup in order to determine the material parameters, we consider an optimal experiment design (OED) problem.

This project is joint work with Benjamin Jurgelucks and Stephan Schmidt from Humboldt-Universität zu Berlin, as well as Nadine Feldmann and Leander Claes of the Measurement Engineering Group from Paderborn University.

Combinatorics

First session (Tuesday morning)

11:00 - 11:20

Distinct distances with ℓ_p metrics

Yago Moreno Alonso, University of Bristol
rb18891@bristol.ac.uk

We study Erdős's distinct distances problem under ℓ_p metrics with integer p. We improve the current best bound for this problem from $\Omega(n^{4/5})$ to $\Omega(n^{6/7-\varepsilon})$, for any $\varepsilon > 0$. We also characterize the sets that span an asymptotically minimal number of distinct distances under the ℓ_1 and ℓ_∞ metrics.

This work was done as part of the *Polymath REU* program under the supervision of Dr. Adam Sheffer.

The authors: Moaaz AlQady (The American University in Cairo), Riley Chabot (Princeton University), William Dudarov (Carleton College), Linus Ge (University of Rochester), Mandar Juvekar (University of Rochester), Srikanth Kundeti (Rutgers University), Neloy Kundu (Lafayette College), Kevin Lu (Georgia Institute of Technology), Yago Moreno (University of Bristol), Sibo Peng (North Carolina State University), Samuel Speas (University of California, Berkeley), Julia Starzycka (University of Illinois at Chicago), Henry Steinthal (Lafayette College), and Anastasiia Vitko (Wesleyan University).

11:20 - 11:40

On circles enclosing many points

Alejandra Martínez-Moraian, Universidad de Alcalá
alejandra.martinezm@uah.es

Let S be a set of n red and n blue points in the plane in general position, that is, no three points are colinear and no four points are cocircular. We prove that S contains a red and a blue point such that every circle passing through them encloses at least $n(1 - \frac{1}{\sqrt{2}}) - o(n)$ other points of S. This is a two-colored version of a problem posed by Neumann-Lara and Urrutia. The proofs make use of properties of higher order Voronoi diagrams, in the spirit of the work of Edelsbrunner, Hasan, Seidel and Shen on this topic. This is a joint work with Mercè Claverol and Clemens Huemer (Universitat Politècnica de Catalunya).

11:40 - 12:00

Correspondence colouring of multigraphs

Xinyi Xu, London School of Economics and Political Science
x.xu46@lse.ac.uk

We study a variant of graph colouring called *correspondence colouring*, or *DP-colouring*, which generalises list colouring. In addition to each vertex having its own list of allowed colours, each edge comes with a matching between the lists of colours of its end vertices; the matching can be partial. A proper correspondence colouring is an assignment for each vertex of a colour from its own list such that the end vertices of each edge get assigned colours that are not matched. The correspondence chromatic number χ_c of a graph is the minimum list size required for every vertex, so that a proper colouring exists for any correspondence on the edges and any lists of colours of that size. Whilst multiple edges do not provide additional constrains in standard or list colouring, the situation is quite different for correspondence colouring, since each edge has its own matching.

We study how certain graph operations will affect the correspondence chromatic number of a multigraph. For example, unlike for standard or list colouring, in which adding one edge may only increase χ_c by at most 1, we present multigraphs for which adding one edge leads to an arbitrary large increase in χ_c.

This is joint work with Jan van den Heuvel.

12:00 - 12:20

Constructing balanced coloured orientations of transitive graphs as a factor of iid

Aranka Hrušková, Central European University
umim.cist@gmail.com

We study a special type of local algorithms on both amenable and non-amenable infinite graphs.

Starting with percolation clusters, we construct balanced coloured orientations of the square and triangular lattices. That is, we show that these are Schreier graphs (in a factor of iid way) of the free groups F_2 and F_3 respectively.

Among non-amenable graphs, we focus on the infinite $2d$-regular trees T_{2d}, where $d \geq 2$. For each T_{2d}, we consider an auxiliary $2d$-regular bipartite graph $\widetilde{T}_{2d}$ such that a perfect matching on $\widetilde{T}_{2d}$ is equivalent to a balanced orientation of T_{2d}. The matching is then obtained thanks to the expansion properties of the auxiliary graph.

Joint work with Ferenc Bencs and László Márton Tóth.

12:20 - 12:40

Rooted structures in graphs

Samuel Mohr, Masarykova univerzita
mohr@fi.muni.cz

A transversal of a partition is a set which contains exactly one element from each member of the partition and nothing else. Given a graph G and a subset T of its vertex set, a rooted minor of G is a minor such that T is a transversal of its branch set. In this talk, we present several concepts of attaching rooted relatedness to ideas in structural graph theory. As an example, we discuss sufficient conditions for a rooted accentuation of Hadwiger's conjecture: Given a transversal of a colouring of a graph G, does G contain a rooted minor traversed by the transversal?

12:40 - 13:00

Applying Skolem sequences to gracefully label new families of triangular windmills

Ahmad H. Alkasasbeh, Memorial University of Newfoundland
ahmad84@mun.ca

A function f is a *graceful labelling* of a graph $G = (V, E)$ with m edges if f is an injection $f\colon V \to \{0, 1, 2, \ldots, m\}$ such that each edge $uv \in E$ is assigned the label $|f(u) - f(v)|$, and no two edge labels are the same. If a graph G has a graceful labelling, we say that G itself is graceful.

In this work, we proved Rosa's conjecture for a new family of triangular cacti: Dutch windmills of any order with three pendant triangles.

This is joint work with Dr. Danny Dyer and Dr. Nabil Shalaby.

Second session (Tuesday afternoon)

15:00 - 15:20

A graphical calculus for integration over random diagonal unitary matrices

Satvik Singh, Indian Institute of Science Education and Research
satviksingh2@gmail.com

We provide a graphical calculus for computing averages of tensor network diagrams with respect to the distribution of random vectors containing independent uniform complex phases. Our method exploits the order structure of the partially ordered set of uniform block permutations. A similar calculus is developed for random vectors consisting of independent uniform signs, based on the combinatorics of the partially ordered set of even partitions. We employ our method to extend some of the results by Johnston and MacLean on the family of local diagonal unitary invariant matrices. Furthermore, our graphical approach applies just as well to the real (orthogonal) case, where we introduce the notion of triplewise complete positivity to study the condition for separability of the relevant bipartite matrices. Finally, we analyze the twirling of linear maps between matrix algebras by independent diagonal unitary matrices, showcasing another application of our method.

This is a joint work with Dr. Ion Nechita from Laboratoire de Physique Théorique, Université de Toulouse, CNRS, UPS, France.

15:20 - 15:40

Towards a partial solution of the decomposition number problem for symmetric groups

Diego Millan Berdasco, Queen Mary University of London
d.millanberdasco@qmul.ac.uk

The most important open problem in the modular representation theory of the symmetric group is finding the number and multiplicity of the composition factors for a given Specht module. We call this the "decomposition number problem". In characteristic 0, Specht modules are just the simple modules of $\mathbb{F}S_n$, but in positive characteristic they may no longer be simple. We will survey the rich interplay between the representations of S_n and combinatorics of partitions to compute the upper bound for Specht modules of weight 3. If time allows, we will show which of these attain maximal number of composition factors and how this upper bound constitutes a promising step towards the solution of the decomposition number problem in weight 3.

15:40 - 16:00

Model theory and metric approximate subgroups

Arturo Rodríguez Fanlo, University of Oxford
Arturo.RodriguezFanlo@maths.ox.ac.uk

An approximate subgroup is a combinatorial concept that models an object similar to a subgroup up to a constant error. In 2011, using model theory, it was found a connexion between finite approximate subgroups and Lie groups (see E. Hrushovski "Stable group theory and approximate subgroups"). This result was the starting point used to finally give a complete classification of the finite approximate subgroups (see E. Breuillard, B. Green and T. Tao "The structure of approximate subgroups"). In this talk we will see a generalization to the case of metric groups.

16:00 - 16:20

Matrix rigidity, algebraic and combinatorial techniques

Yangxinyu Xie, University of Texas at Austin
yx4247@utexas.edu

The density of a matrix $A \in \mathbb{F}^{NN}$, is the number of nonzero elements drawn from the field $\mathbb{F}$, denoted by $\text{dens}(A)$. The rigidity of a matrix $A \in \mathbb{F}^{NN}$ is the function $\mathcal{R}_A^{\mathbb{F}}(r)\colon \{1,\ldots,N\} \to \{1,\ldots,N^2\}$ defined by

$$\mathcal{R}_A^{\mathbb{F}}(r) := \min i | \exists B, \text{dens}(B) = i, \text{rank}(A+B) \leq r$$

In 1977, Valiant motivated the definition of matrix rigidity from the analysis of circuit complexity. Moreover, via a probabilistic argument, Valiant showed that a random matrix over a finite field $\mathbb{F}$ has rigidity $\Omega((N-r)^2/\log N)$. However, explicit constructions of a rigid matrix seem hard. Historically, algebraic techniques allow researchers to show that totally regular matrices have rigidity $\Omega(\frac{N^2}{r} \cdot \log(\frac{N^2}{r}))$. On the combinatorial side, the application of Paturi-Pudlák Dimensions not only gives us the same $\Omega(\frac{N^2}{r} \cdot \log(\frac{N^2}{r}))$ lower bound, but also hints toward why explicit lower bound is hard.

This presentation is comprised of a short survey of the algebraic and combinatorial techniques that led the explicit lower bound of matrix rigidity mentioned above, as well as some recent combinatorial angles toward matrix rigidity, such as rigid sets, and their implications.

16:20 - 16:40

Synchronizing times for *k*-sets in automata

Natalie Behague, Ryerson University
nbehague@ryerson.ca

An automaton consists of a finite set of states and a collection of functions from the set of states to itself. An automaton is *synchronizing* if there is a word (that is, a sequence of functions) that maps all states onto the same state. Černý's conjecture on the length of the shortest such word is probably the most famous open problem in automata theory. We consider the closely related question of determining the minimum length of a word that maps k states onto a single state.

For synchronizing automata, we have improved the upper bound on the minimum length of a word that sends some triple to a single state from $0.5n^2$ to $\approx 0.19n^2$. I will discuss this result and some related results, including a generalisation of this approach to an improved bound on the length of a synchronizing word for 4 states and 5 states.

This is joint work with Robert Johnson.

Third session (Wednesday morning)

11:00 - 11:20

Hypergraph decompositions into cycles

Marcus Kühn, Universität Heidelberg
kuehn@informatik.uni-heidelberg.de

We prove that for any k and $\varepsilon > 0$, there is an ℓ_0 such that any k-uniform hypergraph with a sufficiently large number of vertices n and minimum codegree $(1/2 + \varepsilon)n$ admits a fractional decomposition into tight cycles of length ℓ whenever $\ell \geq \ell_0$. To this end, we introduce a new method for finding a set $\mathcal{C}$ of sufficiently long cycles of equal length such that every edge is contained in roughly the same number of cycles in $\mathcal{C}$ by exploiting the rapid mixing of certain Markov chains.

This is joint work with Felix Joos.

11:20 - 11:40

Embedding spanning trees in dense directed graphs

Amarja Kathapurkar, University of Birmingham
axk516@bham.ac.uk

In 2001, Komlós, Sárközy and Szemerédi proved that for sufficently large n, every n-vertex graph with minimum degree at least $n/2 + o(n)$ contains a copy of every n-vertex tree with maximum degree at most $O(n/\log n)$. We discuss an approach to showing the corresponding result for directed graphs. That is, the goal is to show that for sufficiently large n, every n-vertex directed graph with minimum semi-degree at least $n/2 + o(n)$ contains a copy of every n-vertex oriented tree whose underlying maximum degree is at most $O(n/\log n)$.

This would improve a recent result of Mycroft and Naia, which requires the oriented trees to have underlying maximum degree at most Δ, for any constant Δ and sufficiently large n. In contrast to the previous work on spanning trees in dense directed or undirected graphs, our approach does not use Szemerédi's regularity lemma.

This is joint work with Richard Montgomery.

11:40 - 12:00

A degree sequence result for 3-uniform hypergraphs

Joseph Hyde, University of Birmingham
jfh337@bham.ac.uk

The study of asymptotic minimum degree thresholds that force matchings and tilings in hypergraphs is a lively area of research in combinatorics. A key breakthrough in this area was a result of Hàn, Person and Schacht who proved that the asymptotic minimum vertex degree threshold for a perfect matching in an n-vertex 3-graph is $\left(\frac{5}{9} + o(1)\right)\binom{n}{2}$. In this talk we present an improvement on this result, giving a family of degree sequence results, all of which imply the result of Hàn, Person and Schacht, and additionally allow one third of the vertices to have degree $\frac{1}{9}\binom{n}{2}$ below this threshold. Furthermore, we show that this result is, in some sense, tight. Joint work with Candida Bowtell.

12:00 - 12:20

Inverse Turán numbers

Nika Salia, Alfréd Rényi Institute of Mathematics
nika.salia@renyi.hu

For given graphs G and F, the Turán number $\mathrm{ex}(G, F)$ is defined to be the maximum number of edges in an F-free subgraph of G. Foucaud, Krivelevich and Perarnau and later independently Briggs and Cox introduced a dual version of this problem wherein for a given number k, one maximizes the number of edges in a host graph G for which $\mathrm{ex}(G, H) < k$. Addressing a problem of Briggs and Cox, we determine the asymptotic value of the inverse Turán number of the paths of length 4 and 5 and provide an improved lower bound for all paths of even length. We also obtain bounds on the inverse Turán number of even cycles giving improved bounds on the leading coefficient in the case of C_4.

This is joint work with Ervin Győri, Casey Tompkins and Oscar Zamora.

12:20 - 12:40

Almost all optimally coloured complete graphs contain a rainbow Hamilton path

Stephen Gould, University of Birmingham
SPG377@bham.ac.uk

A subgraph H of an edge-coloured graph is called rainbow if all of the edges of H have different colours. In 1989, Andersen conjectured that every proper edge-colouring of K_n admits a rainbow path of length $n-2$. We show that almost all optimal edge-colourings of K_n admit both (i) a rainbow Hamilton path and (ii) a rainbow cycle using all of the colours. This result demonstrates that Andersen's Conjecture holds for almost all optimal edge-colourings of K_n and answers a recent question of Ferber, Jain, and Sudakov. Our result also has applications to the existence of transversals in random symmetric Latin squares. This is joint work with Tom Kelly, Daniela Kühn, and Deryk Osthus.

Fourth session (Thursday afternoon)

15:00 - 15:20

Properties of line graphs and their relations to associated graphs

Fabio Buccoliero, Vrije Universiteit Amsterdam
f.buccoliero@vu.nl

Line graphs were introduced to translate problems regarding edges of a graph to the often easier problems regarding vertices. In this talk, we study line graphs in their own right: After giving the definition, we will introduce line graphs by presenting some of their properties. We will then see how these properties relate to the corresponding properties of associated graphs; namely the graph which can be obtained from the 'edge-to-vertex' procedure, and its edge complement. For example, we determine the graphs whose edge complement is isomorphic to their line graph.

15:20 - 15:40

Signed graphs: theory and applications

Bruno Ordozgoiti, Aalto University
bruno.ordozgoiti@aalto.fi

In signed graphs, edges are labeled with either a positive or a negative sign. This small modification greatly enriches the representation capabilities of graphs. However, many of their properties undergo significant changes, and some polynomial-time solvable combinatorial problems become computationally hard when signs are taken into account. In this talk we will discuss some of the most important properties of signed graphs, with an emphasis on spectral theory. In addition, we will review recent applications and the role of signed graphs in recent breakthroughs.

15:40 - 16:00

Resilience for tight Hamiltonicity in random hypergraphs

Vincent Pfenninger, University of Birmingham
vxp881@bham.ac.uk

A classical result in random graph theory states that $p = \log n/n$ is the probability threshold for Hamiltonicity in the Erdős-Rényi random graph $G(n, p)$. Lee and Sudakov generalised Dirac's theorem to random graphs by proving that if $p = \omega(\log n/n)$, then $G(n, p)$ asymptotically almost surely has the property that any spanning subgraph of $G(n, p)$ with minimum degree at least $(1/2 + o(1))np$ contains a Hamilton cycle. We prove a similar result for tight Hamilton cycles in hypergraphs. More precisely, we show that given any $k \geq 3$ and $\gamma > 0$, if $p \geq n^{\gamma-1}$, then the k-uniform random hypergraph $G^{(k)}(n, p)$ asymptotically almost surely has the property that any spanning subgraph of $G^{(k)}(n, p)$ with minimum codegree at least $(1/2 + \gamma)np$ contains a tight Hamilton cycle.

This is joint work with Peter Allen and Olaf Parczyk.

16:00 - 16:20

Hamiltonicity in random subgraphs of the hypercube

Alberto Espuny Díaz, Technische Universität Ilmenau
alberto.espuny-diaz@tu-ilmenau.de

We study Hamiltonicity in random subgraphs of the hypercube $\mathcal{Q}^n$. Our first main theorem is an optimal hitting time result. Consider the random process which includes the edges of $\mathcal{Q}^n$ according to a uniformly chosen random ordering. Then, with high probability, as soon as the graph produced by this process has minimum degree $2k$, it contains k edge-disjoint Hamilton cycles, for any fixed $k \in \mathbb{N}$. Secondly, we obtain a perturbation result: if $H \subseteq \mathcal{Q}^n$ satisfies $\delta(H) \geq \alpha n$ with $\alpha > 0$ fixed and we consider a random binomial subgraph $\mathcal{Q}^n_p$ of $\mathcal{Q}^n$ with $p \in (0, 1]$ fixed, then with high probability $H \cup \mathcal{Q}^n_p$ contains k edge-disjoint Hamilton cycles, for any fixed $k \in \mathbb{N}$. In particular, both results resolve a long standing conjecture, posed e.g. by Bollobás, that the threshold probability for Hamiltonicity in the random binomial subgraph of the hypercube equals $1/2$. Our techniques also show that, with high probability, for all fixed $p \in (0, 1]$ the graph $\mathcal{Q}^n_p$ contains an almost spanning cycle. Our methods involve branching processes, the Rödl nibble, and absorption.

The results in this talk are joint work with Padraig Condon, António Girão, Daniela Kühn and Deryk Osthus.

16:20 - 16:40

Lagrangian Kinchin families

Víctor J. Maciá Medina, Washington University in St. Louis
victor.macia@wustl.edu

In this talk, we will introduce new techniques to find asymptotic formulas for counting sequences of combinatorial structures. In particular, we will focus on the Lagrange equation and its consequences. All these results are strongly related to finding asymptotic formulas for the coefficients of analytic functions.

Later on, we will prove the classical Meir-Moon theorem using these techniques. Let ψ be an analytic function on a disc and $f(z) = z\psi(f(z))$ the Lagrange equation for ψ, under certain conditions, we have

$$a_n \sim \sqrt{\frac{\psi(\tau)}{2\pi\psi''(\tau)}} \frac{1}{n^{3/2}} \left(\frac{\psi(\tau)}{\tau}\right)^n, \quad \text{when } n \to \infty.$$

where a_n are the coefficients of f. The proof of this result will be much simpler when using this approach that uses random variables and the central limit theorem.

To conclude, we will introduce a connection between the random, Galton-Watson, trees and the combinatorial trees proving that both things are the same under certain conditions. We will use this connection to find an asymptotic formula for the probability of having n nodes, when $n \to \infty$.

Control theory and optimization

First session (Wednesday morning)

11:00 - 11:20

Solving the length constrained K-drones rural postman problem

Paula Segura, Universitat de València
pausema2@alumni.uv.es

In this talk, I address the Length Constrained K-Drones Rural Postman Problem (LC K-DRPP). This is a continuous optimization problem where a fleet of homogeneous drones have to jointly service (traverse) a set of (curved or straight) lines of a network. Unlike the vehicles in classical arc routing problems, drones can fly directly between any two points in the plane. Moreover, since the range of the drones is restricted, the length of each route is limited by a maximum distance. Some applications for drone ARPs include inspection of pipelines, railway or traffic monitoring. To deal with this problem, LC K-DRPP instances are digitized by approximating each line by a polygonal chain with a finite number of points and allowing drones to enter and exit each line only at these points, thus obtaining instances of the Length Constrained K-vehicles Rural Postman Problem (LC K-RPP). I present here a formulation, some valid inequalities for the LC K-RPP and a branch-and-cut algorithm for its solution, as well as a matheuristic algorithm capable of providing good solutions for large LC K-RPP instances. Computational experiments to assess the performance of both algorithms are presented on several sets of instances from the literature. This is a joint work with Ángel Corberán, José María Sanchis, Isaac Plana and James Campbell.

11:20 - 11:40

From the Lipschitz to the Lipschitz lower semicontinuity modulus for linear semi-infinite systems

María Jesús Gisbert Francés, Universidad Carlos III de Madrid
mgisbert@est-econ.uc3m.es

Inspired by previous works of D. Klatte (1985,1987), we introduce the intermediate property between Aubin's and Lipschitz lower semicontinuity: the Lipschitz lower semicontinuity-star (Lipschitz-lsc*, in brief). Specifically, we study the relevancy of this property and its relationship between the others through their moduli for linear semi-infinite systems. Roughly speaking, the Lipschitz lower semicontinuity properties measure the rate of local contraction (in a neighborhood of a nominal solution fixed in advance) of the feasible set under data perturbations, while the Aubin property deals with the rate of local variation (contraction/expansion) of this set. One of the main contributions of this work consists of proving that the corresponding moduli do coincide when confined to the frameworks of full or right-hand-side perturbations. Nevertheless, we find notable differences when we deal with left-hand-side perturbations.

This is joint work with M. J. Cánovas (canovas@umh.es), R. Henrion (henrion@wias-berlin.de) and J. Parra (parra@umh.es).

11:40 - 12:00

On optimizing piecewise linear functions

Timo Kreimeier, Humboldt-Universität zu Berlin
Timo.Kreimeier@hu-berlin.de

The development of algorithms to optimize functions of a certain class is an essential part of applied mathematics and of central importance for industrial applications.

In this talk, we will focus on the class of piecewise linear functions. Throughout we assume that the function is given in the so-called abs-linear form. This helps us to deal with the non-smoothness of the piecewise linear functions, which in our case is caused by the absolute value. Based on this, Andreas Griewank and Andrea Walther developed an algorithm for the unconstrained optimization for functions of this class. It is discussed how to extend this algorithm to solve constrained optimization problems where not only the target function itself but also the constraints can be represented in an abs-linear form.

This algorithm is a joint development with Andrea Walther and Andreas Griewank.

12:00 - 12:20

A Harten's approach to shape optimization

Sergio López-Ureña, Universitat de València
sergio.lopez-urena@uv.es

In some optimization problems, the optimal set of parameters to be determined describes the graph of a smooth function. In this talk we will deal with an optimization problem oriented to the design of competition sailboats, in which it is intended to mold some parts of a boat submerged under water in order to reduce drag.

The proposed optimization method combines *Harten's multiresolution analysis* with polynomial interpolation techniques.

12:20 - 12:40

Global optimization via the dual SONC cone and linear programming

Janin Heuer, Technische Universität Braunschweig
janin.heuer@tu-braunschweig.de

Using the dual cone of sums of nonnegative circuits (SONC), we provide a relaxation of the global optimization problem to minimize an exponential sum and, as a special case, a multivariate real polynomial. Our approach builds on two key observations. First, that the dual SONC cone is contained in the primal one. Hence, containment in this cone is a certificate of nonnegativity. Second, we show that membership in the dual cone can be verified by a linear program. We implement the algorithm and present initial experimental results comparing our method to existing approaches.

This is joint work with Mareike Dressler, Helen Naumann, and Timo de Wolff.

12:40 - 13:00

On the distance-constrained enough arc routing problem

Miguel Reula Martín, Universitat de València
miguel.reula@uv.es

Recent technological advances allow many logistic problems to be solved more easily and with less cost. In particular, in meter reading problems, the companies can remotely collect the consumption data of their customers due to radio frequency technology (RFID). In some cases, a vehicle with a receiver travels through a neighborhood and, if it gets within a certain distance of a meter, the receiver is able to record the gas, water, or electricity consumption. Therefore, the vehicle does not need to traverse all the streets where there are meters but a subset of them that are close enough to all meters. In this application, we deal with a generalization of this problem in which a fleet of vehicles is available, the Distance-Constrained Close Enough Arc Routing Problem (DC-CEARP) also known as Generalized Directed Rural Postman Problem. The vehicles have to leave from and return to the depot and the length of their routes must not exceed a maximum distance (or time). We propose a new formulation for the DC-CEARP and an exhaustive study of the associated polyhedron by describing several new families of valid inequalities is carried out. Moreover, has been implemented a matheuristic algorithm and a branch-and-cut incorporating separation algorithms for the new valid inequalities. This is a joint work with Ángel Corberán, Isaac Plana and José María Sanchis.

Second session (Thursday afternoon)

15:00 - 15:20

Hierarchical control of the semilinear wave equation

José Antonio Villa Morales, Universidad Nacional Autónoma de México
antvilla06@gmail.com

Control problems arise from several physical phenomena. Let Ω an open set and $\omega, \mathcal{O} \subset \Omega$ open sets in the n dimensional euclidean space. For two functions f and v define the initial value problem

$$\begin{array}{lll} \partial_t^2 y - \Delta y + F(y) = f 1_\omega + v 1_{\mathcal{O}} & \text{in} & Q \\ y = 0 & \text{in} & \Sigma \\ y(0) = y_0, y_t(0) = y_1 & \text{in} & \Omega \end{array}$$

where $\lim_{x \mapsto \infty} \frac{F(s)}{s \log(|s|)} = 0$. The Hierarchical control problem consist in the follower control f should minimise a functional S and the leader control v should steer the solution to zero in a positive time T, i.e., $y(T) = 0$. To solve this problem the Stackelberg strategy is used:

I) Given v find a follower control $f[v]$ such that the functional S is minimised.
II) Find the control v such that the solution $y(T) = 0$ for a positive time.

To solve the null controllability problem of v is necessary to calculate suitable energy estimates resulting from the general Carleman inequalities. The difficulty rising from this semi-linear problem bind us to fin better estimates for potentials in $L^\infty(0, T; L^2(\Omega))$ and for the energy estimate and find suitable Sobolev embeddings to apply the Kakutani fixed point theorem to solve the non linear problem.

15:20 - 15:40

A data-driven method for formation control of multi-agent systems

Verónica Arroyo Rodríguez, ICMAT - Universidad Complutense de Madrid
vearroyo@ucm.es

Methods such as deep learning and reinforced learning have been successful in modeling and controlling many dynamical systems. For such methods to achieve the desired performance which appears in the real world, but we don't know which dynamics follow, we often require multiple systems runs over a large sum of data that sometimes may not be available in several scenarios. In this talk, we present a method based on quadratic programming to approximate the Lagrangian associated with the distance-based formation problem from limited data from an observation of the trajectory. We also show how to obtain bounds for the approximation errors and provide the results obtained in a two-dimensional system of the evolution of three and four agents reaching a desired shape. This is joint work together with Leonardo J. Colombo.

15:40 - 16:00

Some recent results about the controllability of the heat equation.

Jon Asier Bárcena Petisco, Universidad Autónoma de Madrid
jon.barcena@uam.es

The heat equation is the most basic parabolic PDE. Its null controllability was proved in the 90s for all C^2 domains by Fursikov and Imanuvilov. However, this is not the end of the story: there are still plenty of interesting questions about the controllability of the heat equation. In this talk we discuss briefly some of them and present recent progress in answering them. A first one is to determine if the heat equation is indeed null controllable in all Lipschitz domains. A second one is to determine the evolution of the cost of the controllability when the diffusion vanishes and there is a transport term. In particular, we focus on the heat equation with Robin and mixed boundary conditions. A third and last one is the controllability of the stochastic heat equation with a random diffusion.

16:00 - 16:20

A neural network for learning-based shape control of multi-agent systems

Manuela Gamonal, ICMAT (CSIC-UCM-UAM-UC3M)
manuela.gamonal@icmat.es

Nowadays, many different fields are evolving to adapt themselves to the new possibilities that data analysis can provide. One of those emerging lines of research is Control Theory. This area is facing more and more challenges as technology develops, challenges which usually cannot be solved satisfactorily with classical approaches. The increasing necessity of new solutions

or procedures as well as the possibility of extracting data for them makes control theory an interesting field to explore in the seek of new solutions based on data, creating a whole new field named data-driven control. Although the application of Machine Learning techniques to control problems is not new, currently there is a new impulse in this direction, trying to combine the possibilities of data science and machine learning. In that line, the main objective of this talk is to introduce the design and implementation of a Lagrangian Neural Network and how it can be applied for multi-agent Lagrangian systems, in particular for an application to formation control of multi-agent systems, with the specific purpose of training a neural network for modelling Lagrangian systems from data. This is a joint work with Leonardo Colombo.

16:20 - 16:40

Geometric control of two quadrotors carrying a rigid rod via elastic cables

Jacob Goodman, ICMAT (CSIC-UAM-UCM-UC3M), La Caixa Foundation
jacob.goodman@icmat.es

This talk presents the design of a geometric trajectory tracking controller for the cooperative task of two quadrotor UAVs (unmanned aerial vehicles) carrying and transporting a rigid bar, which is attached to the quadrotors via inflexible elastic cables. The elasticity of the cables together with techniques of singular perturbation theory allows a reduction in the model to that of a similar model with inelastic cables. In this reduced model, a controller is designed such that the rod exponentially tracks a given desired trajectory for its position and attitude, under some assumptions on the initial error. It is then shown that exponential tracking in the reduced model corresponds to exponential tracking of the original elastic model. This is a joint work with Leonardo Colombo.

16:40 - 17:00

Control of wave equations

Vaibhav Kumar Jena, Queen Mary University of London
v.k.jena@qmul.ac.uk

The controllability problem for a given ODE/PDE system is the following: *Is it possible to drive the system from any initial state to any final state, using a suitable control?* We consider the problem in the case of wave equations. One of the methods to solve this is by using Carleman estimates, which are used to show suitable unique continuation results for PDEs. We present a novel Carleman estimate for ultrahyperbolic operators. A special case of this will then be used to obtain improved controllability results for wave equations.

Dynamical systems and ODEs

First session (Tuesday afternoon)

15:00 - 15:20

Probing the precessing bar model for the Galactic warp origin

Celsa Pardo-Araujo, Universitat Politècnica de Catalunya
pardoaraujocelsa@gmail.com

About 50% of external galaxies present a warped disc when they are seen edge-on, and our galaxy is also one of them. It was first detected in dust and gas, and recent works also show it in the stellar component using different tracers: Cepheids, young stars in star forming regions, Red Giants,etc. However, the origin of such deformation in the disc is not clear. Among the different theories found in the literature, we focus on a recent one which involve precessing bar models. In this approach, we use a model where the bar is precessing due to a misalignment of the angular velocity vector and the angular momentum vector of the system. In this work, we further explore the viability of this theory for the formation of the warp in our Galaxy, by quantifying the effect of a precessing bar in the proper motions of stars. For the latter we chose two different regions: one end of the Galactic bar and a segment of the disk close to the Sun. Furthermore,we explore the viability of Gaia data to validate these results.

Collaborators: Romero-Goméz, M. and Sanchez-Martin, P.

15:20 - 15:40

A computational approach to capture the uncertainty of real data: application to breast tumour growth

David Martínez-Rodríguez, Universitat Politècnica de València
damarro3@upv.es

In this work we describe a computational approach to seek suitable random variables of model input parameters for the random Pielou logistic equation. The objective is to fit the probability density function (PDF) of the solution of the randomized logistic model to the PDF of sampled data corresponding to breast tumor volume. To allocate uncertainty in sampled data and in the model input parameters we take advantage of the Principle of Maximum Entropy (PME).

This is joint work with C. Burgos (clabursi@upv.es) and E. López-Navarro (ellona1@upv.es).

15:40 - 16:00

Population dynamics of *Ctenosaura bakeri*

Lorenzo Ruaro, Università di Bologna
lorenzo.ruaro.93@gmail.com

The *Ctenosaura bakeri* is an iguana species endemic to the island of Utila, a small island off the eastern coast of Honduras. It is currently one of the species of the genus *Ctenosaura* most

threatened with extinction, having its conservation status labelled as "Critically Endangered" by the IUCN Red List.

The goals of this study are to give some mathematical insights on the intrinsic trend of the whole population and to analyse the influence of the greater threats to the survival of the species (such as sex dependent hunting and habitat destruction).

We will use a transition matrix approach to investigate the intrinsic trend of the population and we will provide arguments for the estimation of the different parameters.

For the influence of the threats we will take a deterministic approach using systems of ODEs and DDEs, investigating the stationary points and their stability and giving prediction through simulations for the evolution of the population.

We will also introduce a first model for the occurence of hybridization with another iguana species of the island.

The achieved results are summarized and still open questions stated at the end.

16:00 - 16:20

Global stability and sensitivity of an SQIR model with infectivity during quarantine

Thiago Kfouri De Angelis, Universidade de São Paulo
thiagokda@ime.usp.br

This is a joint work with Luís Eduardo dos Santos Lopes.

Due to the propagation of direct transmission diseases, the analysis of compartmental models to measure the impact of prophylactic actions becomes a necessity. One of those actions, that motivated this work, is the isolation of infected people during medical care. So, we studied a SQIR model, in which due to flexibilization of isolating norms, the contagion occurres from the encounter of susceptible with infected and quarantined. The system is studied through qualitative theory of ODEs and numerical simulations.

The basal number R_0 is obtained through Van den Driessche and Watmough's method. That parameter limits the stable manifolds of its two equilibrium points. Using Lasalle's and Cetaev's theorems of Liapunov's theory, it was proven that when $R_0 < 1$ the disease-free equilibrium is globally asymptotic stable and the endemic equilibrium is globally asymptotic stable when $R_0 \geq 1$ and unstable otherwise.

Finally, sensitivity analysis was done through numerical simulations, changing the parameters and observing the curve of infected. Increasing the number of infected that enter quarantine, it was observed a significant reduction in the number of infected, however the curve maintained its shape. Reducing the contagion rate, reduced the number of infected and deformed the curve, retarding the pinnacle of cases, being more effective.

16:20 - 16:40

Subharmonics in a class of planar periodic predator-prey models

Eduardo Muñoz-Hernández, Universidad Complutense de Madrid
eduardmu@ucm.es

This contribution analyzes the existence of positive subharmonics of arbitrary order in the planar periodic Volterra predator-prey model. If the support of the birth rate of the prey intersects the support of the death rate of the predator then the existence of positive subharmonics can be derived with a refinement of the Poincaré–Birkhoff theorem. However, in the *degenerate* case when these supports do not intersect, then, the last Poincaré theorem fails. Still in these degenerate situations, some techniques of local and global bifurcation theory combined with a refinement of the Poincaré–Birkhoff theorem provide us with the existence of positive subharmonics of arbitrary order.

This is a joint work with Julián López-Gómez (Universidad Complutense de Madrid) and Fabio Zanolin (Udine University).

Second session (Wednesday morning)

11:00 - 11:20

Hamiltonians of Painlevé IV equation

Adam Ligęza, Uniwersytet Warszawski
al320166@students.mimuw.edu.pl

In this talk I am going to speak about Painlevé equations, especially about the fourth Painlevé equation P_{IV}. I will show three different Hamiltonians and Hamiltonian systems connected with P_{IV} (that are Okamoto's Hamiltonian, rational Hamiltonian and Kecker's Hamiltonian) and present a method how to match them by using algebraic geometry tools. I will show how that can be done by matching surface roots on the level of Picard lattice. Moreover I will check whether our matching is cannonical. This is a joint work with Galina Filipuk and Anton Dzhamay and Alexander Stokes.

11:20 - 11:40

On the growth and fixed points of solutions of linear differential equations with entire coefficients

Mohamed Abdelhak Kara, Université de Mostaganem
mohamed.kara.etu@univ-mosta.dz

Many authors have studied the growth of solutions of high order complex linear differential equations of the form

$$f^{(k)} + A_{k-1}(z)f^{(k-1)} + \cdots + A_0(z)f = 0, \tag{1}$$

where $k \geq 2$ and the coefficients $A_0, \ldots, A_{k-1}$ are entire functions with iterated $[p, q]$-order.

In this presentation, we use a more general concept called the φ-order to investigate the growth and the fixed points of entire solutions of equation (1) when the growth of an arbitrary coefficient $A_s(s = 0, \ldots, k-1)$ dominates the other coefficients. Our results are improvements and extensions of some previous results. This is joint work with Benharrat Belaïdi.

11:40 - 12:00

Anosov endomorphisms on the 2-torus: regularity of foliations and rigidity

Marisa Cantarino, Universidade Estadual de Campinas
m211292@dac.unicamp.br

In hyperbolic dynamics, a widely studied class of maps is that of *Anosov diffeomorphisms*, which are hyperbolic at each point with uniform expansion and contraction rates. The more general class of *Anosov endomorphisms*, which are local diffeomorphisms and not necessarily invertible, is much less understood.

In a recent preprint, F. Micena proves, among other results, that Anosov endomorphisms of the 2-torus with the property that each point has only one unstable direction and such that each stable leaf is dense satisfies that coincidence of Lyapunov exponents of the map and its linearization implies C^∞ conjugacy between then.

We extend this result for the semiconjugacy between any Anosov endomorphism of $\mathbb{T}^2$ and its linearization, and apply it to obtain a rigidity result. More specifically, we get an equivalence between smooth semiconjugacy and a regularity condition on unstable leaves of this endomorphism. This regularity condition is known as *UBD property* (*uniform bounded density property*), introduced by F. Micena and A. Tahzibi, and it means that the disintegration of volume on foliated boxes has densities uniformly bounded with respect to the Lebesgue measure on each leaf.

This is a joint work with Régis Varão.

12:00 - 12:20

Computing rotation numbers in the circle with a new algorithm

Salvador Borrós Cullell, Universitat Autònoma de Barcelona
sborros@mat.uab.cat

For a given continuous cirlce map $f\colon \mathbb{S}^1 \to \mathbb{S}^1$ of degree one and one given lifting of f, $F\colon \mathbb{R} \to \mathbb{R}$, there is always a well defined rotation interval, $\mathrm{Rot}(F)$. We present an efficient algorithm to compute rotation intervals that is based on the computation of the rotation number of a monotone circle map of degree one with constant section. This algorithm is specially useful for non-invertible and non differentiable maps, for which there are very few algorithms to compute rotation intervals.

This algorithm is compared with two existing ones by computing the time each takes to plot the Devil's Staircase. The proposed new algorithm turns out to be a thousand times quicker and more exact than the existing ones in the best case scenario.

Finally, using the proposed algorithm we plot the Arnold Tongues and rotation intervals of three functions, two of which are non-differentiable. Therefore, they cannot be quickly computed with the existing algorithms.

This is a joint work with Prof. Lluís Alsedà i Soler.

12:20 - 12:40

A uniqueness theorem for the solution of a conformable inverse problem

Fatma Ayça Çetinkaya, Mersin Üniversitesi
faycacetinkaya@mersin.edu.tr

We consider a conformable boundary value problem generated by a conformable Sturm-Liouville operator and boundary conditions which include conformable derivatives of order α, $0 < \alpha < 1$. We discuss the evolution of the Weyl solution and Weyl function and we prove the uniqueness theorem for the solution of the inverse problem with respect to the Weyl function.

Third session (Thursday afternoon)

15:00 - 15:20

About 4-crossing periodic orbits

Mariana Queiroz Velter, Universidade Federal de Goiás
marianaqueirozvelter@gmail.com

We characterize the crossing periodic orbits of piecewise smooth vector fields ou discontinuous vector fields that intersect the switching manifold at four points. We show examples and, in some situations, we provide necessary conditions for the existence of such orbits.

15:20 - 15:40

Dynamics on planar lattices

Mia Jukic, Leiden University
m.jukic@math.leidenuniv.nl

It is a well-known result that solutions of the Allen Cahn equation on $\mathbb{R}^n$ develop interface region whose dynamics is governed by the mean curvature flow with a constant drift term. That result inspired us to see if the solution of a discrete Allen-Cahn equation on a two dimensional lattice also exhibits similar behaviour.

We first show that if the initial perturbation u_0 is bounded, then the solution u also develops a traveling interface region, which is represented via discrete curve γ. Moreover, we make a connection between the evolution of the interface region and the solution of a discrete mean curvature flow with a drift term. We show that, in contrast with the results for continuous Allen Cahn equation, drift term is not constant anymore as a consequence of a spatial anisotropy of the lattice. This is a joint work with Hermen Jan Hupkes.

15:40 - 16:00

On linear generic inhomogeneous boundary-value problems for differential systems in Sobolev spaces

Olena Atlasiuk, Institute of Mathematics of the NAS of Ukraine
hatlasiuk@gmail.com

For the systems of ordinary differential equations of an arbitrary order on a compact interval, we study a character of solvability of the most general linear boundary-value problems in the Sobolev spaces W_p^n, with $n \in \mathbb{N}$ and $1 \leq p \leq \infty$. We find the indices of these Fredholm problems and obtain a criterion of their well-posedness. Each of these boundary-value problems relates to a certain rectangular numerical characteristic matrix with kernel and cokernel of the same dimension as the kernel and cokernel of the boundary-value problem. The condition for the sequence of characteristic matrices to converge is found. We obtain a constructive criterion under which the solutions to these problems depend continuously on the small parameter ε at $\varepsilon = 0$, and find the degree of convergence of the solutions. Also applications of these results to multipoint boundary-value problems are obtained.

This is joint work with Prof. Volodymyr Mikhailets.

Geometry

First session (Tuesday morning)

11:00 - 11:20

On invariant operations of a manifold with a linear connection and an orientation

Raúl Martínez-Bohórquez, Universidad de Extremadura
raulmb@unex.es

The theory of natural operations in differential geometry has a long history. Model results in this theory produced explicit descriptions of all natural operations of a certaind kind; that way, there appeared characterisations for many various differential operations, such as those for the exterior differential, the Lie bracket or the characteristic classes in Riemannian geometry.

To be presented is a follow-up on a previous work (*On the uniqueness of the torsion and curvature operators*, by Gordillo-Merino, Martínez-Bohórquez and Navarro, RACSAM 2019). There, an important result by J. Slovak was reformulated in the language of sheaves and ringed spaces, which allowed us to give characterisations of the torsion tensor of linear connections as well as another of the curvature tensor of symmetric linear connections, much in the spirit of the classical results mentioned above. The nice properties of ringed spaces allows us to export this machinery to the setting of manifolds endowed with a linear connection and an orientation, in order to improve the aforementioned characterisations of the torsion and curvature tensors, to describe the space of natural forms and to give a result on the existence of field equations on this environment.

This is a joint work with Adrián Gordillo-Merino and José Navarro.

11:20 - 11:40

On discrete isoperimetric type inequalities

Eduardo Lucas, Universidad de Murcia
eduardo.lucas@um.es

The isoperimetric inequality is one of the oldest and most outstanding results in mathematics, and can be summarized by saying that the Euclidean balls minimize the surface area measure $\mathrm{S}(\cdot)$ (Minkowski content) among those compact convex sets with prescribed positive volume $\mathrm{vol}(\cdot)$ (Lebesgue measure). There exist many different versions and extensions of this result, which have led to remarkable consequences in many branches of mathematics. It admits the following "*neighbourhood* form": for any compact convex set $K \subset \mathbb{R}^n$, and all $t \geq 0$,

$$\mathrm{vol}(K + tB_n) \geq \mathrm{vol}(rB_n + tB_n), \tag{1}$$

where $r > 0$ is such that $\mathrm{vol}(rB_n) = \mathrm{vol}(K)$ and B_n denotes the (closed) Euclidean unit ball.

In this talk we discuss and show a discrete analogue of the isoperimetric inequality in its form (1) for the *lattice point enumerator* $\mathrm{G}_n(K) = \#(K \cap \mathbb{Z}^n)$ of a bounded subset $K \subset \mathbb{R}^n$: we determine sets minimizing the functional $\mathrm{G}_n\big(K + t[-1,1]^n\big)$, for any $t \geq 0$, among those bounded sets K with given positive lattice point enumerator. We also show that this new discrete inequality implies the classical result for compact sets.

This is about a joint work with David Iglesias and Jesús Yepes Nicolás (Universidad de Murcia).

11:40 - 12:00

On Grünbaum type inequalities

Francisco Marín Sola, Universidad de Murcia
francisco.marin7@um.es

Given a compact set $K \subset \mathbb{R}^n$ of positive volume, and fixing a hyperplane H passing through its centroid, we find a sharp lower bound for the ratio $\mathrm{vol}(K^-)/\mathrm{vol}(K)$, depending on the concavity nature of the function that gives the volumes of cross-sections (parallel to H) of K, where K^- denotes the intersection of K with a halfspace bounded by H. When K is convex this inequality recovers a classical and powerful result by Grünbaum, whose generalizations and extensions to other settings are of high interest nowadays in Geometric Analysis and beyond.

In this talk we will give an introduction to the Grünbaum inequality and we will show and discuss our results. This is a joint work with Jesús Yepes Nicolás.

12:00 - 12:20

Convergence of manifolds with totally bounded curvature

Manuel Mellado Cuerno, Universidad Autónoma de Madrid
manuel.mellado@uam.es

When we study the topological consequences of the curvature, one of the most succesful tools is the Gromov-Hausdorff distance. It allows us studying the convergence of manifolds under some metric constrictions. In this talk, we will focus the convergence with totally bounded sectional curvature. We will explain some of the most important results in the area (Cheeger-Gromov, Fukaya, Naber-Tian), and the collapse situation with codimension 1 on the limit due to Roos. Finally, we will show some results where the Gomov's Filling Radius appears.

12:20 - 12:40

The Ambrose-Singer theorem for general homogeneous manifolds with applications to symplectic geometry

José Luis Carmona Jiménez, Universidad Complutense de Madrid
jcarmo03@ucm.es

The main result of this talk provides a characterization of reductive homogeneous spaces equipped with some geometric structure (non necessarily pseudo-Riemannian) in terms of the existence of certain connection. The result generalizes the well-known result of Ambrose and Singer for Riemannian homogeneous spaces, as well as its extensions for other geometries found in the literature. The manifold must be connected and simply connected, the connection

has to be complete and has to satisfy a set of geometric partial differential equations. If the connection is not complete or the manifold is not simply-connected, the result provides a characterization of reductive locally homogeneous manifolds. Finally, we use these results in the local framework to classify with explicit expressions reductive locally homogeneous almost symplectic, symplectic and Fedosov manifolds.

This is joint work with M. Castrillón López.

Second session (Tuesday afternoon)

15:00 - 15:20

Recent results on interpolation by minimal surfaces

Ildefonso Castro-Infantes, Universidad de Murcia
ildefonso.castro@um.es

Complex analysis and minimal surfaces are strongly connected via the Weierstrass representation formula. This fact has been exploited recently to construct lots of examples of such surfaces with different properties. We would present in this talk the first results dealing with interpolation in the setting of minimal surfaces. These results are inspired by the classical Weierstrass interpolation theorem for holomorphic functions and are proved using techniques coming from complex analysis.

More concretely, given an open Riemann surface M, we would construct conformal minimal immersions $M \to \mathbb{R}^n$, $n \geq 3$, such that the values of the immersion at some points of M are prescribed. We would show in the talk different results and the ideas of how to prove them.

15:20 - 15:40

On inaudibility of Jacobi operator related properties on closed Riemannian manifolds

José Manuel Fernández-Barroso, Universidad de Extremadura
ferbar@unex.es

It is well known the importance of the Riemannian curvature tensor in differential geometry. Moreover, the Jacobi operator determines the curvature operator on every geodesic.

A property is said to be audible if it can be determined from the eigenvalues of the Laplace–Beltrami operator. In this sense, there are audible properties, for example the volume or the total scalar curvature of a closed Riemannian manifold. In the last years, some properties related to the curvature operator have been proved to be inaudible, for example the D'Atri property (i.e., the local geodesic symmetries are volume preserving, up to sign) or the type $\mathcal{A}$ property (i.e., the Ricci tensor is cyclic parallel).

In our work, we study the audibility of some properties related to the Jacobi operator on closed Riemannian manifolds.

This is a joint work with Teresa Arias-Marco.

15:40 - 16:00

On isoptic curves and isochordal-viewed curves

David Rochera, Universitat de València
David.Rochera@uv.es

Given $\phi \in]0, \pi[$ and a planar curve α, the ϕ-isoptic of α is the locus of points from which the curve α is seen under a constant angle $\pi - \phi$. Isoptic curves have been studied thoroughly for smooth convex curves in the last decades. In this talk we will outline an introduction to this kind of curves and the non-convex case will be addressed. The construction of isoptics reminds to other kinematic problems, such as those related to Holditch's theorem. In this setting, a new kind of curves, called isochordal-viewed curves, will be defined and some of their properties will be given.

16:00 - 16:20

Curves and surfaces from magnetic spheres

Henriette-Sophie Lipschütz, Freie Universität Berlin
Henriette.Lipschuetz@fu-berlin.de

In various branches of science, attention is paid to the interaction of so-called Neodym magnets, i.e. identically magnetized spheres of unit radius, due to different aspects. Meanwhile, researchers investigated the minimal energy structures of a collection of spheres on a theoretical level as well as using computer simulations. Every configuration made of magnetized spheres induces a graph: Its vertices are given by the centers of the spheres and two vertices form an edge if they belong to tangential spheres. Every embedded graph fulfilling this definition can be covered with spheres made from say wood. Using magnetized spheres as mentioned, their interaction can lead either to stable configurations or to collapsing ones. The latter induces a change of the underlying graph. Starting with a configuration made from highly symmetric building blocks as loops, we investigate whether a given configuration is stable and on what curves or surfaces the centers of mass of the spheres lie on. Therefore, the process is formulated as a minimization problem in terms of a quadratic problem which is analyzed to classify the problem and to improve the simulation.

16:20 - 16:40

L^2 Harmonic 1-form, minimal surface and Thurston norm of hyperbolic manifolds

Xiaolong Hans Han, University of Illinois at Urbana-Champaign
xhan25@illinois.edu

We study the application of minimal surfaces and Hodge theory on hyperbolic manifolds in relating Thurston norm and L^2-norm for cohomology of non-compact hyperbolic manifolds, generalizing an inequality of Brock-Dunfield.

Third session (Wednesday morning)

11:00 - 11:20

New topological constructions of steady Euler flows

Robert Cardona, Universitat Politècnica de Catalunya
robert.cardona@upc.edu

The Euler equations model the dynamics of an ideal fluid and can be formulated in any Riemannian manifold. The recent introduction of the concept of Eulerisable flow (vector fields which are steady solutions to the Euler equations for some metric) provided a framework to unveil the geometric wealth of steady ideal fluids. In this talk we will first introduce Arnold's structure theorem, which leads to emphasize in two different kinds of solutions: integrable and Beltrami type Euler flows. Next, we will look at new topological constructions of both of these types in dimension 3 and higher odd dimensions.

11:20 - 11:40

On the singular Weinstein conjecture and existence of escape orbits

Cédric Oms, Universitat Politècnica de Catalunya
cedric.oms@upc.edu

In this talk we will state a generalization of the Weinstein conjecture in the case of contact structures that admit codimension 1 singularities called b-contact forms. We will prove a weak version of this conjecture for 'generic' contact forms: more precisely, we show that its associated Reeb vector fields admit escape orbits. This is done by connecting the dynamics of those vector fields to Beltrami vector fields (coming from hydrodynamics) and making use of genericity results for eigenfunctions of the Laplacian à la Uhlenbeck. This is joint work with Eva Miranda and Daniel Peralta–Salas.

11:40 - 12:00

(Non-)unique limits of geometric flows

James Kohout, University of Oxford
kohout@maths.ox.ac.uk

The unique asymptotic limit problem asks whether a gradient flow that converges along a sequence of times $t_i \to \infty$ will converge to a *unique* asymptotic limit along every sequence of times $t \to \infty$. While examples of finite dimensional gradient flows that asymptote to a circle of critical points show that this property does not hold in general, Stanisław Łojasiewicz proved that this uniqueness of asymptotic limits holds for gradient flows of real analytic functions in finite dimensions. In his seminal work, Leon Simon provided a framework for tackling this problem for certain parabolic gradient flows of real analytic functionals. In the first part of the talk we will describe the role that the so-called Łojasiewicz-Simon inequality plays in the study of uniqueness of asymptotic limits. We will then discuss the unique asymptotic limit problem for a geometric flow which is designed to evolve a map describing a closed surface in a given

target manifold into a parametrization of a minimal surface. This talk is based on joint work with Melanie Rupflin and Peter M. Topping.

12:00 - 12:20

Covariant reduction by fiberwise actions

Álvaro Rodríguez Abella, ICMAT - Universidad Complutense de Madrid
alvrod06@ucm.es

Symmetries represent a central tool in the geometric analysis of Mechanical systems. When a group of symmetries acts on the phase space of a (Lagrangian) system, the quotient by this action of both the space and the variational principle is known as Reduction. In the case of Mechanics, this produces the well-known Lagrange-Poincaré equations which have many applications in the literature. In the realm of Field Theories, similar results have been also obtained. However, the typical nature of symmetries involved in the most relevant classical Field Theories is local and has not been addressed so far. In this case, symmetries are given by fiberwise actions of Lie group bundles. The main instance of this situation are gauge symmetries. The goal of our contribution is the determination of the reduction procedure when a first order Lagrangian is G-invariant, being G a gauge group.

Mathematical aspects of computer sciences

First session (Wednesday morning)

11:00 - 11:20

Efficient sampling from feasible sets of SDPs and volume approximation

Apostolos Chalkis, National & Kapodistrian University of Athens
achalkis@di.uoa.gr

We present algorithmic, complexity, and implementation results on the problem of sampling points from a spectrahedron, that is the feasible region of a semidefinite program.

Our main tool is geometric random walks. We analyze the arithmetic and bit complexity of certain primitive geometric operations that are based on the algebraic properties of spectrahedra and the polynomial eigenvalue problem. This study leads to the implementation of a broad collection of random walks for sampling from spectrahedra that experimentally show faster mixing times than methods currently employed either in theoretical studies or in applications, including the popular family of Hit-and-Run walks. The different random walks offer a variety of advantages, thus allowing us to efficiently sample from general probability distributions, for example the family of log-concave distributions which arise in numerous applications. We focus on two major applications of independent interest: (i) approximate the volume of a spectrahedron, and (ii) compute the expectation of functions coming from robust optimal control.

We exploit efficient linear algebra algorithms and implementations to address the aforementioned computations in very high dimension. In particular, we provide a C++ open source implementation of our methods that scales efficiently, for the first time, up to dimension 200. We illustrate its efficiency on various data sets.

11:20 - 11:40

Value-positivity for matrix games

Raimundo Saona, IST Austria
rasa200@gmail.com

Zero-sum matrix games are the most basic problem in Game Theory and are closely related to the classical optimization problem of Linear Programming (LP). A central question in Stability Analysis is robustness to small perturbations. We consider polynomial matrix games where, along with the basic matrix for the error-free term, other matrices characterize the polynomial dependency to error terms. The classical work of Mills characterizes the first derivative of the value function under linear perturbations. We consider the *value-positivity*, *uniform value-positivity* and *functional form* problems, where (a) the value-positivity ensures that, for every sufficiently small error, there is a strategy to guarantee that the value is at least the value of the error-free case; (b) the uniform value-positivity ensures that there is a strategy to guarantee that, for every sufficiently small error, the value is at least the value of the error-free case; and (c) the functional form computes the analytical form of the value of the game upon perturbations. The above problems are related to the robustness of LPs to errors in the parameters. Our main contributions are the following. First, we present illuminating examples. Second, we present

polynomial-time algorithms to decide the value-positivity and functional form problems for polynomial matrix games, and show that the uniform value-positivity problem is NP-complete.

11:40 - 12:00

Flag codes of maximum distance

Miguel Ángel Navarro-Pérez, Universidad de Alicante
miguelangel.np@ua.es

Let q be a prime power and $\mathbb{F}_q$ denote the finite field of q elements. A *flag code* on the vector space $\mathbb{F}_q^n$ is a nonempty collection of sequences of nested subspaces (*flags*). They were recently introduced as a subspace codes generalization. Associated to a flag code, we can naturally define a set of subspace codes: its *projected codes*. In this talk, we will focus on the family of flag codes attaining the maximum possible distance and we will characterize them in terms of their projected codes.

This is joint work with Clementa Alonso-González and Xaro Soler-Escrivà.

12:00 - 12:20

Multiquadratic rings and oblivious linear function evaluation

Alberto Pedrouzo-Ulloa, Universidade de Vigo
apedrouzo@gts.uvigo.es

The Ring Learning with Errors (RLWE) problem has been widely used for the construction of new quantum-resistant cryptographic primitives. Most of the existing RLWE-based schemes make use of power-of-two cyclotomic rings due to their good performance and simplicity. This talk explores the replacement of power-of-two cyclotomic rings by multiquadratics. We show that for polynomials with n coefficients, the cost of the polynomial operations can be reduced from $\mathcal{O}(n \log n)$ multiplications to $\mathcal{O}(n)$ multiplications and $\mathcal{O}(n \log n)$ additions. Finally, we discuss the benefits that these rings can bring about when implementing the OLE (Oblivious Linear Function Evaluation) primitive, which is a basic block used in many Secure Multiparty Computation (MPC) protocols.

This is joint work with Juan Ramón Troncoso-Pastoriza, Nicolas Gama, Mariya Georgieva and Fernando Pérez-González.

Mathematical physics

First session (Tuesday morning)

11:00 - 11:20

Recurrence coefficients of orthogonal polynomials with different weights and Painlevé equations

Jie Hu, University of Macau
hujie_0610@163.com

We use different methods to study the connection between recurrence coefficients of semi-classical orthogonal polynomials and solutions of discrete Painlevé equations.

Hypergeometric weights and Bäcklund transformations of Painlevé VI this wok is joint with Galina Filipuk (University of Warsaw) and Yang Chen (University of Macau). We derive a second-order nonlinear difference equation from the nonlinear difference system about the recurrence coefficients of hypergeometric weights and present explicit formulas showing how this difference equation arises from the Bäcklund transformations of the Painlevé VI.

Laguerre wights and discrete Painlevé Equations joint with Anton Dzhamay (University of Northern Colorado) and Yang Chen. We study a certain recurrence relation that can be used to generate ladder operators for the Laguerre Unitary ensemble from the point of view of Sakai's geometric theory of Painlevé equations. We give a more detailed example of the appearance of discrete Painlevé equations and present how to reduce such recurrences to some canonical discrete Painlevé equations.

11:20 - 11:40

Surface flexibility delays droplet impact and entraps more air

Nathaniel Henman, University College London
nat.henman.15@ucl.ac.uk

The role that surface flexibility plays in an air cushioned impact of a liquid droplet is considered. Assuming small density and viscosity ratios between the liquid and air, a reduced system of integro-differential equations is derived governing the liquid droplet free-surface shape and the pressure in the thin air film. To close the system, a membrane-type model is used for the shape of the flexible surface. The magnitude and shape of the surface deformation is determined by the surface properties, including surface stiffness. We solve the set of governing equations numerically and present a parametric study by varying the stiffness of the surface. It is found that lowering the surface stiffness results in reduced contact pressure, but bubble entrapment still occurs and in fact increases in magnitude (for a water droplet of radius 1 mm and approach speed of 1 m s^{-1}, a reduction in surface stiffness corresponding to a maximum surface deflection of 6 μm results in a 30% increase in the initial horizontal bubble extent and a 40% increase in the height, when compared to an impact with a flat rigid surface). Finally, a case is considered in the limit of large flexibility, where an implied simpler pressure-shape relationship leads to a large time analysis, with good agreement to the numerical results. A quantitative connection with recent experiments is also found.

11:40 - 12:00

Incompatibility in quantum information theory

Faedi Loulidi, Université Paul Sabatier
loulidi@irsamc.ups-tlse.fr

The discovery of quantum mechanics gave rise to different important aspect that differs completly from our classical exterior reality. More precisely thoose days quantum information theory provide tools to understand quantum world from a new point of view with several applications. One of the crucial concept that differs the calssical and the quantum world is the incompatibility notion. Such notion was investigate from different point of view, in our recent work we developped and investigate a new notion of incompatibility that i shall present.

This is joint work with my supervisor Ion Nechita.

12:00 - 12:20

State extension for quantum field theory in curved spacetime

Diego Vidal-Cruzprieto, The University of York
diego.vidal@york.ac.uk

A state ω is a normalised positive linear functional on a $*$-algebra. In Quantum Field Theory (QFT), the physical observables generate a $*$-algebra $\mathcal{A}$ and the state allows us to assign to each observable $a \in \mathcal{A}$ an expectation value $\omega(a)$ that the observable has when the physical system is in a particular state ω. Currently, QFT is our best description of matter and its interactions. It makes essential use of the concept of state because it corresponds to a measurement of the physical system being studied.

There is a special class of states in QFT denominated Hadamard states which are often deemed as physically reasonable states because, among other reasons, they possess the same singular structure as the Minkowski vacuum state–the state of maximal symmetry and minimum energy for a region of spacetime without gravity.

It is known that Hadamard states defined on a region of spacetime might not have extensions (as Hadamard states) to larger regions. In this talk, I will present a method to extend said states to a larger region by sacrificing a "safety margin", while preserving the Hadamard form. Then, I will show this is possible to do this in several scenarios, including Minkowski spacetime. Work in progress with Chris Fewster.

12:20 - 12:40

Rational soliton solutions for the derivative non-linear Schrödinger equation

Paz Albares Vicente, Universidad de Salamanca
paz.albares@usal.es

A generalized study and characterization of the integrability properties of the derivative nonlinear Schrödinger equation in $1+1$ dimensions is presented. A Lax pair is derived for this equation by means of a Miura transformation and the singular manifold method, together with the associted binary Darboux transformations. This procedure will allow us to contruct a wide class of rational soliton-like solutions for this equation. These results are part of a joint work with P. G. Estévez and J. D. Lejarreta.

Second session (Tuesday afternoon)

15:00 - 15:20

Cubic microlattices embedded in nematic liquid crystals: a Landau-de Gennes study

Razvan-Dumitru Ceuca, BCAM - Euskal Herriko Unibertsitatea
rceuca@bcamath.org

We consider a Landau-de Gennes model for a connected cubic lattice scaffold in a nematic host, in a dilute regime. We analyse the homogenised limit for both cases in which the lattice of embedded particles presents or not cubic symmetry and then we compute the free effective energy of the composite material.

In the cubic symmetry case, we impose different types of surface anchoring energy densities, such as quartic, Rapini-Papoular or more general versions, and, in this case, we show that we can tune any coefficient from the corresponding bulk potential, especially the phase transition temperature.

In the case with loss of cubic symmetry, we prove similar results in which the effective free energy functional has now an additional term, which describes a change in the preferred alignment of the liquid crystal particles inside the domain.

Moreover, we compute the rate of convergence for how fast the surface energies converge to the homogenised one and also for how fast the minimisers of the free energies tend to the minimiser of the homogenised free energy.

15:20 - 15:40

Recent progress on the vortex filament equation for regular polygons

Sandeep Kumar, BCAM-Basque Center for Applied Mathematics
skumar@bcamath.org

Due to its simplicity and geometric structure, the vortex filament equation (VFE) secures a unique place in the fluid literature. The equation is a model for the dynamics of a vortex filament (e.g. smoke rings, tornadoes, etc.) in a 3-D inviscid incompressible fluid. In this talk, we discuss some of the recent work based on its behavior for the polygonal-shaped filaments curves. More precisely, we describe the evolution of VFE for a regular polygon as an initial datum using theoretical and numerical tools. It will also be shown that the evolution of a single point located on the curve follows a multifractal trajectory which can be compared with the graph of Riemann's non-differentiable function. Finally, we briefly comment on the corresponding evolution in the hyperbolic space.

This is joint work with Francisco de la Hoz (UPV/EHU) and Luis Vega (BCAM, UPV/EHU)

15:40 - 16:00

Covariant brackets in particle dynamics and first order Hamiltonian field theories

Luca Schiavone, Università degli Studi di Napoli Federico II and Universidad Carlos III de Madrid
luca.schiavone@unina.it

Poisson brackets are a central tool within the problem of quantization where it is customary to start with a classical algebra of observables equipped with the Poisson bracket on the phase space and build an algebra of quantum observables in which a Lie product substitute the Poisson bracket in a suitable sense. On the other hand, many physical theories appear to be manifestly covariant with respect to some (Lie) group. Accordingly, it would be relevant to retain such a covariance within the quantization in order to obtain a quantum theory manifestly covariant with respect to the same group as its classical counterpart. In this respect, it is necessary that the "classical" bracket is covariant with respect to the same group. This is not the case, for instance, for the Poisson bracket of Hamiltonian dynamics and its generalization to field theories when the group is the Poincaré one. This is because it is defined on an algebra of observables at a fixed time and, thus, a space-time splitting which brake the covariance is used from the very beginning. We propose a way to define a bracket directly on the space of solutions of the dynamical system. Consequently, such a bracket is covariant with respect to the relevant group by construction both in particle dynamics and in field theory. We also show the relation with the standard Poisson bracket of Hamiltonian dynamics. The mathematical setting we will use is the multisymplectic formulation of first order Hamiltonian field theories.

16:00 - 16:20

Principles of least action in physics and their geometry

Manuel Lainz, ICMAT
manuel.lainz@icmat.es

"A trajectory c will be followed by the system if and only if c is a critical point of the action among all trajectories with the same endpoints as c." If by the *action* we mean the integral of a Lagrangian function L along c, this is *Hamilton's least action principle* which can be used to describe most physical theories (geometric optics, classical mechanics, electrodynamics, general relativity, etc.), and has applications in other fields (for example, solving optimal control problems and finding geodesics in Riemannian and Finsler geometry). Its solutions have a nice geometric characterization: they are integral curves of a Hamiltonian vector field on a symplectic manifold.

Part of my current research deals with a generalization of this principle: the so-called *Herglotz principle*. Here the Lagrangian not only depends on the positions and velocities, but also on the action itself. Hence, the action is no longer the integral of the Lagrangian, but it is the solution of a non-autonomous ODE. This principle allows us to model new problems, such as some dissipative systems in mechanics (where energy is lost), thermodynamics, and some modified optimal control systems. This principle is also related to Hamiltonian systems, but switching symplectic by contact geometry.

In this talk we will compare both principles, their applicability and the geometric properties of their solutions.

16:20 - 16:40

Ehrenfest wind-tree model is dynamically richer than the Lorentz gas

Hassan Attarchi, Georgia Institute of Technology
hattarchi@gatech.edu

We consider a physical Ehrenfests' Wind-Tree model where a moving particle is a hard ball rather than (mathematical) point particle. We demonstrate that a physical periodic Wind-Tree model is dynamically richer than a physical or mathematical periodic Lorentz gas. Namely, the physical Wind-Tree model may have diffusive behavior as the Lorentz gas does, but it has more superdiffusive regimes than the Lorentz gas. The new superdiffusive regime where the diffusion coefficient $D(t) \sim (\ln t)^2$ of dynamics seems to be never observed before in any model.

This is joint work with Leonid A. Bunimovich and Mark Bolding.

Number theory

First session (Thursday afternoon)

15:00 - 15:20

Permutation binomials of index $q^{e-1} + \cdots + q + 1$ over $\mathbb{F}_{q^e}$

Javier Santiago, University of Puerto Rico
javier.santiago16@upr.edu

We denote the finite field of order q by $\mathbb{F}_q$. A polynomial in $\mathbb{F}_q[x]$ is a *permutation polynomial* over $\mathbb{F}_q$ if it induces a permutation of $\mathbb{F}_q$. Binomials of index $q^{e-1} + \cdots + q + 1$ over $\mathbb{F}_{q^e}$ with $e \geq 2$ are of the form $x^r(x^{q-1} + a)$ where $a \in \mathbb{F}_{q^e}^*$. In this paper we present several existence and nonexistence results for permutation binomials over $\mathbb{F}_{q^e}$ of this type. As a consequence, we obtain a complete characterization of such permutation binomials over $\mathbb{F}_{q^2}$, $\mathbb{F}_{q^3}$, $\mathbb{F}_{q^4}$, $\mathbb{F}_{p^5}$, and $\mathbb{F}_{p^6}$ where p is an odd prime. This extends previous results obtained by Li et al. and Liu for $e = 2$ and $e = 3$ with odd q, respectively.

This is joint work with Ariane M. Masuda and Ivelisse Rubio.

15:20 - 15:40

The K-theory of diamonds

Shanna Dobson, California State University Los Angeles
Shanna.Dobson@calstatela.edu

A perfectoid space is an adic space covered by affinoid adic spaces of the form $Spa(R, R^+)$ with R perfectoid. Let $Perfd$ be the category of perfectoid spaces. Let $Perf \subset Perfd$ be the subcategory of perfectoid spaces in characteristic p. Let $\mathcal{Y}$ be a pro-étale sheaf on $Perf$. $\mathcal{Y}$ is a diamond if $\mathcal{Y}$ can be expressed as the quotient X/R of a perfectoid space X of characteristic p by a pro-étale equivalence relation $R \subset X \times X$ such that R is a perfectoid space with $s, t : R \to X$ pro-étale. We survey Efimov's definition of K-theory and give a preliminary outline of the K-theory of diamonds.

15:40 - 16:00

Distributions of character sums

Ayesha Hussain, University of Bristol
ayesha.hussain@bristol.ac.uk

Over the past few decades, there has been a lot of interest in partial sums of Dirichlet characters. Montgomery and Vaughan showed that these character sums remain a constant size on average and, as a result, a lot of work has been done on the distribution of the maximum. In this talk, we will investigate the distribution of these character sums themselves, with the main goal being to describe the limiting distribution as the prime modulus approaches infinity. This is motivated by Kowalski and Sawin's work on Kloosterman paths.

16:00 - 16:20

The action of a Hopf Galois structure on the p-part of a dihedral degree $2p$ extension

Daniel Gil-Muñoz, Universitat Politècnica de Catalunya
daniel.gil.munoz@upc.edu

A finite extension of fields L/K is said to be Hopf Galois if there is some pair $(H, \langle,\rangle)$ of a Hopf algebra H and a linear action $\langle,\rangle: H \otimes_K L \to L$ such that the map $L \otimes_K H \to \mathrm{End}_K(L)$ induced by $\langle,\rangle$ is an isomorphism of K-vector spaces. Such a pair need not to be unique and it is what we call a Hopf Galois structure. It plays the role of the Galois group in a Galois extension, being the last one a particular case of a Hopf Galois extension. Using this approach in local Galois module theory, for an extension L/K of local fields one may ask about the module structure of the integers ring $\mathcal{O}_L$ over objects in the different Hopf Galois structures of L/K. In this talk we address these kind of questions for the degree p subextensions of a dihedral degree $2p$ extension of $\mathbb{Q}_p$, where p is an odd prime. The action of their Hopf Galois structures can be described in terms of Lucas sequences. This is a joint work with Anna Rio.

16:20 - 16:40

Involutions of the form $x^m(x^{\frac{q-1}{2}} + a)$ over $\mathbb{F}_q$

Lillian González-Albino, University of Puerto Rico
lillian.gonzalez2@upr.edu

Polynomials over finite fields that permute the elements of the field are called **permutation polynomials**. Permutation polynomials over finite fields have many applications ranging from cryptography, and combinatorics to the theory of computation. For many of these applications, it is important to find permutation polynomials with a small memory footprint that are easy to implement. A good option is to use **involutions**, which are functions that coincide with their own inverse. In 2017, Castro et al. gave explicit formulas for monomial involutions over $\mathbb{F}_q$ and their fixed points. In 2018, Zheng et al. characterized involutions of the form $x^m h(x^s)$ over $\mathbb{F}_q$, but explicit formulas for m and the amount of fixed points were not given. Our focus for this talk will be on explicit formulas for both involutions of the form $x^m(x^{\frac{q-1}{2}} + a)$ over $\mathbb{F}_q$ and their fixed points, where q is odd.

16:40 - 17:00

Permutation polynomials over finite fields and factorization

Tekgül Kalaycı, Sabancı University
tekgulkalayci@sabanciuniv.edu

Let $\mathbb{F}_q$ be the finite field with q elements. A polynomial $f \in \mathbb{F}_q[x]$ is called a permutation polynomial if it induces a bijection from $\mathbb{F}_q$ to $\mathbb{F}_q$. Permutation polynomials over finite fields have been attracting a wide interest, not only because there are many natural (and still open)

problems connected with them, but also because they have vast applications, especially in combinatorics, coding and cryptography.

Factorization of various types of polynomials is also a classical problem. In this talk, we will present recent results on factorization of a large class of permutation polynomials. We also discuss sequences and iterations of permutation polynomials. In particular, we obtain sequences of permutation polynomials with certain factorization patterns.

This is a joint work with Henning Stichtenoth and Alev Topuzoğlu.

PDEs

First session (Tuesday morning)

11:00 - 11:20

Global-in-time $C^{1+\gamma}$ regularity for Cauchy patches

Juan Carlos Cantero, Universitat Autònoma de Barcelona
cantero@mat.uab.cat

In fluid mechanics, the transport equation

$$\begin{cases} \rho_t + v \cdot \nabla \rho = 0, \\ v(\cdot, t) = T(\rho(\cdot, t)), \\ \rho(\cdot, t = 0) = \rho_0. \end{cases} \tag{1}$$

has been widely studied when the operator T produces a velocity field v that has zero divergence (e.g. Euler's equation) or when this divergence is simple enough (e.g. aggregation equation, where div $v(\cdot, t) = -\rho(\cdot, t)$). However, in the general case of compressible fluids (i.e., when the divergence is different from 0), the study of (1) is more involved.

Our particular case corresponds to the evolution of a two dimensional density patch, that is, equation (1) when ρ_0 is the characteristic function of a domain $\Omega_0 \subset \mathbb{C}$. For this case, we know that the solution at any time t is the characteristic function of another domain, that is, $\rho(\cdot, t) = \chi_{\Omega_t}$. We consider that T is a convolution type operator with kernel $K(z) = \frac{1}{2\pi z}$ (Cauchy kernel). In this talk we will explain our main result concerning the regularity of Ω_t. In particular, we will see that, if Ω_0 is a domain of class $C^{1+\gamma}$, then Ω_t also is for any t>0.

This is a joint work with Joan Orobitg and Joan Verdera.

11:20 - 11:40

Time periodic solutions for the 3D quasi-geostrophic system

Claudia García, Universidad de Granada
claudiagarcia@ugr.es

In this talk, we aim to study time periodic solutions for the 3D inviscid quasi–geostrophic model. We show the existence of non trivial rotating patches by suitable perturbation of stationary solutions given by *generic* revolution shapes around the vertical axis. The construction of those special solutions are done through bifurcation theory. In general, the spectral problem is very delicate and strongly depends on the shape of the initial stationary solutions. More specifically, the spectral study can be related to an eigenvalue problem of a self–adjoint compact operator. We are able to implement the bifurcation only from the largest eigenvalues of such operator which are simple. This is a joint work with T. Hmidi and J. Mateu.

11:40 - 12:00

Boundary value problems for a loaded hyperbolic equation

Anton Gilev, Samara University
toshqaaa@gmail.com

In this article we consider the boundary value problem for the loaded hyperbolic equation in the domain $\Omega = (0, T) \times (0, l)$

$$u_{tt} - (au_x)_x + cu + \int_0^l K(x)udx = f,$$

$$u(x,0) = \varphi(x),\ u_t(x,0) = \psi(x),$$
$$u(0,t) = 0,\ u(l,t) = 0.$$

The main objective of the article is to find a solution of this equation with that boundary and initial conditions.

We found restrictions on the input data, in the implementation of which there is a single generalized solution. The proof of the uniqueness of its generalized solution is carried out using a priori estimates and properties of Sobolev spaces. To prove the existence of a generalized solution, we used the Galerkin method in variational form.

12:00 - 12:20

Derivation of the advection-diffusion equation and application to material flow and swarming

Jennifer Weissen, Universität Mannheim
jennifer.weissen@uni-mannheim.de

We derive the (strongly degenerate) advection-diffusion equation as the macroscopic limit of particle systems. On the particle level, we consider a system of ordinary differential equations which describes the movement of the particles including their interactions. Starting from this system, requirements on the particle interaction are detailed and the corresponding limit equation is derived using kinetic theory.

We focus on modeling the transport of stable formations in bounded domains where the transport process is disturbed by interactions with obstacles. These interactions lead to internal perturbations in the formation which are modeled by the diffusion on the macroscopic scale. In the undisturbed situation our model is diffusion free. Whenever the transport process is disturbed, diffusion becomes active. These disturbances are not constant in time but instead depend on time and space.

The properties of the advection-diffusion equation are studied numerically in bounded domains. We illustrate how the advection-diffusion equation can be used to describe transport of cargo on a conveyor belt and movements of biological swarms. The results are compared to a non-local macroscopic model as well as to experimental data. The presented work is joint work with S. Göttlich and D. Armbruster.

Second session (Tuesday afternoon)

15:00 - 15:20

Boundary Harnack inequalities with right hand side

Damià Torres-Latorre, Universitat de Barcelona
damia.torres@gmail.com

We prove new boundary Harnack inequalities in Lipschitz domains for equations with a right hand side. Our main result applies to non-divergence form operators with bounded measurable coefficients and to divergence form operators with continuous coefficients, whereas the right hand side is in L^q with $q > n$. Our approach is based on scaling and comparison arguments, and we show that all our assumptions are sharp.

As a consequence of our results, we deduce the $C^{1,\alpha}$ regularity of the free boundary in the fully nonlinear obstacle problem and the fully nonlinear thin obstacle problem.

This is a joint work with Xavier Ros-Oton.

15:20 - 15:40

Boundedness of stable solutions to semilinear equations in low dimensions

Iñigo U. Erneta, BGSMath - Universitat Politècnica de Catalunya
inigo.urtiaga@upc.edu

In this talk, we will discuss the regularity theory of stable solutions to semilinear problems when the dimension of the space is low. A recent result of Cabré, Figalli, Ros-Oton, and Serra shows that, for the Laplacian, stable solutions are bounded up to dimension 9 for *all* nonlinearities. We will study an analogue result for general elliptic operators with an advection term.

15:40 - 16:00

Stability of Gagliardo-Nirenberg inequalites

Nikita Simonov, CEREMADE - Université Paris-Dauphine
simonov@ceremade.dauphine.fr

Optimal constants and optimal functions are known in some functional inequalities. The next question is the stability issue: is the difference of the two terms controlling a distance to the set of optimal functions? A famous example is the case of Sobolev's inequalities: in 1991, Bianchi and Egnell proved that the difference of the two terms (with the optimal constant taken into account) is bounded from below by the distance to the manifold of the Aubin-Talenti functions. In this talk, I will address some results concerning subcritical Gagliardo-Nirenberg inequalities for which explicit constants can be provided. The results are based on a joint work with Matteo Bonforte, Jean Dolbeault, and Bruno Nazaret.

16:00 - 16:20

Regularity results for a class of nonlinear fractional Laplacian and singular problems

Rakesh Arora, Université de Pau et des Pays de l'Adour
rakesh.arora@univ-pau.fr

In this talk, we study the existence, uniqueness, nonexistence, and regularity of weak solutions to the following nonlinear fractional elliptic problem involving singular nonlinearity and singular weights in smooth bounded domain $\Omega \subset \mathbb{R}^N$:

$$(-\Delta)_p^s u = K_\delta(x) u^{-\gamma},\ u > 0 \text{ in } \Omega \text{ and } u = 0 \text{ in } \mathbb{R}^N \setminus \Omega,$$

where $\gamma > 0$ and $K_\delta \in L^\infty_{loc}(\Omega)$ is a non-negative function which behaves like $dist(x, \partial\Omega)^{-\delta}$, for some $\delta \in (0, sp)$. We prove the existence of weak solution in $W^{s,p}_{loc}(\Omega)$ via approximation method. Establishing a new comparison principle of independent interest, we prove the uniqueness of weak solution for $0 \leq \delta < 1 + s - \frac{1}{p}$ and furthermore the nonexistence of weak solution for $\delta \geq sp$. Moreover, by virtue of barrier arguments we study the behavior of minimal weak solution in terms of distance function. Consequently, we prove Hölder regularity up to the boundary and optimal Sobolev regularity for minimal weak solutions.

This is a joint work with Jacques Giacomoni and Guillaume Warnault.

16:20 - 16:40

Modeling the effects of trait-mediated dispersal on coexistence of mutualists

Amila Muthunayake, University of North Carolina at Greensboro
akmuthun@uncg.edu

We analyse positive solutions (u, v) to the steady state reaction diffusion system:

$$\begin{cases} -\Delta u = \lambda u(1-u);\ \Omega \\ -\Delta v = \lambda r v(1-v);\ \Omega \\ \frac{\partial u}{\partial \eta} + \sqrt{\lambda} g(v) u = 0;\ \partial\Omega \\ \frac{\partial v}{\partial \eta} + \sqrt{\lambda} h(u) v = 0;\ \partial\Omega \end{cases}$$

where $\lambda > 0$, $r > 0$ are parameters and $g, h \in C^1([0,\infty),(0,\infty))$ are decreasing functions. This system models the steady states of two species living in a habitat where the interaction is limited to the boundary. Here, λ is directly proportional to the size of the habitat and we will study the ranges of λ where coexistence and nonexistence occurs. Namely, we will consider three cases: (a) $E_1(1, g(0)) = E_1(r, h(0))$, (b) $E_1(1, g(0)) > E_1(r, h(0))$, (c) $E_1(1, g(0)) < E_1(r, h(0))$. Here $E_1(r, K)$ denotes the principal eigenvalue of: $-\Delta z = rEz;\ \Omega$, $\frac{\partial z}{\partial \eta} + K\sqrt{E}z = 0;\ \partial\Omega$.

16:40 - 17:00

The Neumann problem for the fractional Laplacian: boundary regularity

Juan-Carlos Felipe-Navarro, BGSMath - Universitat Politècnica de Catalunya
juan.carlos.felipe@upc.edu

This talk will be devoted to introducing the Neumann problem for the fractional Laplacian, in contrast with the Dirichlet problem, focusing on recent results concerning the boundary regularity.

First, we motivate the problem through a probabilistic interpretation. Next, we give basic properties of the problem. Finally, we are going to present some boundary regularity results, as well as the main ideas for the proofs.

This is a joint work with Alessandro Audrito (ETH-Zurich) and Xavier Ros-Oton (ICREA-UB).

Third session (Wednesday morning)

11:00 - 11:20

H-distributions on Hörmander spaces

Ivana Vojnović, University of Novi Sad
ivana.vojnovic@dmi.uns.ac.rs

We define an important microlocal tool – H-distributions (also called defect distributions), a generalization of H-measures. We consider defect distributions associated to weakly convergent sequences in Hörmander $B_{p,k}$ spaces. Results are applied to linear partial differential equations with non-smooth coefficients and to some semilinear equations.

Let (u_n) be a weakly convergent sequence of approximate solutions of the given semilinear pseudo-differential equation. We obtain relation between appropriate defect distribution and (locally) strong convergence of the sequence (u_n^2).

This is joint work with Ivan Ivec.

11:20 - 11:40

Generalized solution to multidimensional cubic Schrödinger equation with delta potential

Nevena Dugandžija, University of Novi Sad
nevena.dugandzija@dmi.uns.ac.rs

We address the Cauchy problem for the defocusing cubic Schrödinger equation in 2D and 3D and the equation with a delta well potential in 3D. Solutions belong to the Colombeau algebra of generalized functions $\mathcal{G}_{C^1,H^2}$. Physically significant homogeneous problem in 2D and 3D has not yet been treated in this framework, whereas no classical results exist on the equation with delta potential.

Existence and uniqueness in appropriate spaces of generalized functions are proved. Compatibility with the classical H^2 solution is shown for the equation without potential. New estimates of second order derivatives are obtained for the regularized delta potential equation.

This is a joint work with Marko Nedeljkov.

11:40 - 12:00

The structure group for quasi-linear SPDEs via universal enveloping algebras

Pablo Linares, MPI for Mathematics in the Sciences
linares@mis.mpg.de

We consider the approach to quasi-linear singular SPDEs introduced by Otto et. al. This approach, based on regularity structures, allows us interpret the dual of the structure group G as a Lie group arising from a Lie algebra $L \subset \text{End}(T)$ consisting of derivations on the abstract model space T. These derivations in turn are the infinitesimal generators arising from actions on the linear space of pairs (nonlinearities, functions of space-time). We moreover show that, in accordance with Hairer's theory, G is built over a Hopf algebra, which we identify as a coordinate representation of the universal enveloping algebra $U(L)$ of the Lie algebra L. This talk is based on joint work with Felix Otto and Markus Tempelmayr.

12:00 - 12:20

Neumann p-Laplacian problems with a reaction term on metric spaces

Antonella Nastasi, Università di Palermo
antonella.nastasi@unipa.it

We use a variational approach to study existence and regularity of solutions for a Neumann p-Laplacian problem with a reaction term on metric spaces equipped with a doubling measure and supporting a Poincaré inequality. Trace theorems for functions with bounded variation are applied in the definition of the variational functional and minimizers are shown to satisfy De Giorgi type conditions.

12:20 - 12:40

Solvability of boundary value problems for the Schrödinger equation with non-negative potentials

Andrew Turner, University of Birmingham
A.J.Turner@bham.ac.uk

We prove well-posedness for boundary value problems, in the upper half-space, for Schrödinger equations in the form $\text{div}\, A\nabla u - aVu = 0$, where V is a non-negative potential, and A and a are complex-valued, bounded multiplication matrices. The data will be L^2-Neumann and Dirichlet

regularity boundary data and the coefficients are complex Hermitian or of a certain block-type. We build on methods for unperturbed second-order elliptic systems by incorporating the potential V as an additive perturbation of a first order system DB with bounded holomorphic functional calculus. This is joint work with Andrew Morris.

Probability and statistics

First session (Tuesday morning)

11:00 - 11:20

Extrapolation problem for periodically correlated stochastic sequences with missing observations

Iryna Golichenko, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
idubovetska@gmail.com

We consider the problem of optimal estimation of the functional $A\zeta = \sum_{j=1}^{\infty} a(j)\zeta(j)$, which depends on the unknown values of a periodically correlated with period T (T-PC) stochastic sequence $\zeta(j)$ from observations of the sequence $\zeta(j) + \theta(j)$ at points $j \in \{\ldots, -1, 0\} \setminus S$, $S = \bigcup_{l=1}^{s}\{-M_l \cdot T + 1, \ldots, -M_{l-1} \cdot T - N_l \cdot T\}, M_l = \sum_{n=0}^{l}(N_n + K_n),\ M_0 = 0$. $\theta(j)$ is T-PC stochastic sequence uncorrelated with $\zeta(j)$. We assume that coefficients $a(j), j = 1, 2, \ldots,$ satisfy the condition $\sum_{j=1}^{\infty} |a(j)| < \infty$ and are of the form $a(j) = a\left((j - [j/T]T) + [j/T]T\right) = a(\nu + \tilde{j}T) = a(\tilde{j})e^{2\pi i \tilde{j}\nu/T}, \nu = 1, \ldots, T,\ \tilde{j} \geq 0$. We can rewrite the functional $A\zeta$ as a functional of T-variate stationary sequence $\vec{\zeta}(\tilde{j})$, $\tilde{j} \geq 0$, obtained by T-blocking of T-PC sequence $\zeta(j)$, $j \geq 1$.

Formulas for calculation the mean square error and the spectral characteristic of the optimal estimate of functional $A\zeta$ are derived in the case where the spectral densities of the sequences are exactly known. Formulas that determine the least favorable spectral densities and the minimax spectral characteristics are proposed for some classes of admissible spectral densities.

11:20 - 11:40

Decomposition of the option pricing formula for jump-diffusion stochastic volatility models with infinite activity jumps

Zororo Makumbe, Universitat de Barcelona
zmakumma16@alumnes.ub.edu

Let the log returns of an asset $X_t = \log(S_t)$ be defined on a risk neutral filtered probability space $(\Omega, \mathcal{F}, (\mathcal{F}_t)_{t\in[0,T]}, \mathbb{P})$ for some $0 < T < \infty$. Assume that X_t is a stochastic volatility jump diffusion model with infinite activity jumps. We use Itô calculus techniques to obtain versions of the Alòs-type decompositions of the option pricing formula by applying two approaches found in literature. Moreover, we use this decomposition to obtain approximations of option prices for some examples of Lévy processes.

This is a joint work with Prof. Josep Vives.

11:40 - 12:00

A multi-objective sampling design for spatial prediction problem

Elaheh Lotfian, Tarbiat Modares University
e.lotfian@modares.ac.ir

In many fields such as image classification, geostatistical surveys, air pollution, and agricultural modelling, regarding the limitations of resources, time and technology, spatial sampling has a key role. In spatial sampling, a set of sample locations are chosen such that the spatial prediction at unobserved locations be optimal. While, many studies are focused on only one objective function as the predictor variance, the predictor entropy, and so on, in applied problems more than one objective is interested. In this study, the optimization problem of spatial sampling with minimum cost is investigated from both the perspective of covariogram estimation and kriging variance. For this purpose, a bi-objective optimization problem of soil sampling has been considered where the first objective function is the mean total error and the second objective function is the cost of the distance travelled by the sampler. The mean total error is the sum of the ordinary kriging variance and uncertainties of the estimated covariogram parameters. The non-dominated sorting genetic algorithm-II and Taguchi method is applied to this problem. The results show the proper performance of this algorithm in multi-objective spatial sampling for spatial predictions.

This is joint work with Mohsen Mohammadzadeh.

12:00 - 12:20

Robust regularization methods based on Rényi pseudodistance loss

María Jaenada, Universidad Complutense de Madrid
mjaenada@ucm.es

Over the last decades several regularization methods have been developped for sparse high-dimensional regression models. The influence of outliers is particulary awkward in the high dimensional context and so certain robust methods have been considered, including methods using Rényi pseudodistance (RP) loss. Regularization methods simultaneously perform the model selection and the estimation of regression coefficients, merging a loss function based on the residuals and a penalty function inducing sparsity. Different penalties have been proposed, such as LASSO or Adaptative LASSO, a variant which improves the oracle model selection property, or non-concave penalties such as SCAD or MCP, which demostrably overcome the bias problem of the LASSO. We propose to examine the RP loss with the various proposals for the penalties, leading to the differents estimating methods, namely the minimun RP estimator (MNPRPE) penalized with LASSO, MNPRPE penalized with adaptative LASSO and MNPRPE penalized with SCAD and MCP non-concave penalties. We develop an estimating algorithm for each method, focusing on their differences and similarities. Finally, we study the performance of the methods throught a simulation study, and we compare their computing times.

12:20 - 12:40

Opportunistic maintenance under periodic inspections in heterogeneous complex systems

Lucía Bautista Bárcena, Universidad de Extremadura
luciabb@unex.es

A complex system consisting of monitored and non-monitored components is studied. Monitored components are subject to a degradation process, following a homogeneous gamma process. Monitored components fail when their degradation level exceeds a failure threshold. They are subject to a condition-based maintenance: the system is periodically inspected, and if the degradation level of a monitored component reaches a preventive threshold, the component is replaced by a new one. Furthermore, non-monitored components can fail between inspections. Time between these sudden failures follows an exponential distribution. Failures are self-announcing and the repair of the failed component is performed after a fixed delay time. In turn, these repair times are opportunities for preventive maintenance of the monitored components. Assuming a cost for each maintenance action, the expected cost rate of this system is analytically obtained. Numerical examples are given considering identical and non-identical components. Preventive thresholds and time between inspections that minimize the expected cost rate are evaluated. Genetic Algorithm and Monte-Carlo simulation are used to deal with the optimization of the objective cost function and find the optimal maintenance strategy.

This is joint work with Inma T. Castro.

12:40 - 13:00

Diffusivity estimation for activator-inhibitor models: theory and application to intracellular dynamics of the actin cytoskeleton

Gregor Pasemann, Technische Universität Berlin
pasemann@math.tu-berlin.de

Based on the mathematical framework of stochastic reaction-diffusion systems, we develop a statistical theory for diffusivity estimation for spatially extended activator-inhibitor dynamics modelling the evolution of intracellular signaling networks. In order to account for model uncertainties, we consider the problem of joint estimation of diffusivity and parametrized reaction terms. Our theoretical findings are applied to the estimation of effective diffusivity of signaling components contributing to intracellular dynamics of the actin cytoskeleton in the model organism *Dictyostelium discoideum*.

This is joint work with Sven Flemming, Sergio Alonso, Carsten Beta, and Wilhelm Stannat.

Second session (Tuesday afternoon)

15:00 - 15:20

When statistical analysis fails: the natural environment and suicide in the United States

Olga Gutan, Youngstown State University
ogutan@student.ysu.edu

The project initially sought to explain suicide rates in the United States at the county level using demographic, economic, and environmental factors. The study explored whether the quality of the natural environment of a county has a statistically significant impact when predicting suicide rates. The data fit well in the framework of linear regression and the results were within the norms of statistical significance. The findings were consistent with previous research in terms of demographic, economic, and gun law variables. However, some of the Mathematical results appeared to be counter-intuitive given the context of the data set. This presentation is about limitations of the statistical methods employed in this instance. The presentation will also briefly touch upon the larger philosophical question of whether some ideas can are truly impossible to model statistically, or whether it just so happened that a poorly fitting model was chosen.

15:20 - 15:40

Functional space inference with implicit processes in Bayesian neural networks

Simón Rodríguez Santana, ICMAT-CSIC
simon.rodriguez@icmat.es

Bayesian Neural Networks (BNNs) have recently become a popular approach to obtain final predictive distributions in combination with the performance properties of regular neural networks. Recently there has been increasing interest in using *implicit processes* (IPs) as a way of tackling problems inherent to the formulation of BNNs. Approximate methods that take advantage of the properties of IPs seem to be able to have expressive priors and avoid issues concerning the weight-space-optimization, although recent work has only been able to obtain partial results: either they can use expressive priors but with strong constraints in the approximate posteriors (*Variational Implicit Processes*, Ma, Chao *et. al.*, 2019), or the opposite, without being able to fully manage the prior (*Functional variational Bayesian neural networks*, Sun, Shengyang *et. al.*, 2019). We introduce here a new approach that is able to circumvent problems related to both of the previously proposed methods by making use of *inducing points*. We show that we are capable of using IPs both to have flexible final predictions and employ expressive and data-sensible priors. Furthermore, our model is still scalable thanks to the inducing point approximation, all while having good final predictive distributions thanks to its increased expressiveness.

15:40 - 16:00

Cardiac-mechanic parameter inference using statistical emulation

David Dalton, University of Glasgow
d.dalton.1@research.gla.ac.uk

Recent advances in soft-tissue mechanics have yielded realistic models of the dynamics of the heart throughout its pump cycle. Such models have potential for use in the diagnosis of cardiac defects when their parameters are calibrated against patient data.

In this talk, we compare the performance of number of different statistical emulators, including Gaussian processes and neural networks, on parameter inference in the Holzapfel-Ogden model of the left ventricle (LV) of the heart. Computationally efficient emulators are required in order for parameter estimates to be obtained quickly enough for use in real-time clinical decision support. We also introduce a novel approach to accounting for variations in LV geometry via a low dimensional representation obtained using Principal Component Analysis. Modelling these variations is essential for real applications as a given patient's unique LV geometry will only be known at their arrival in clinic. Our results show that local Gaussian process emulation achieves the best parameter estimates. However, we encounter identifiability issues for some parameters, which appears to be an intrinsic limitation of data extracted *in-vivo*. As a result, future work will incorporate additional data obtained from *ex-vivo* studies into the parameter inference problem. This is joint work with Alan Lazarus, Dirk Husmeier and Hao Gao.

16:00 - 16:20

Challenges in the nowadays, disabilities people, sex, race, income and COVID-19, under the mathematical and probabilistic

Paulo de Oliveira, Universidade de São Paulo
poliver@usp.br

The term disability means a physical, intellectual or sensory permanent or temporary nature, which limits the ability to perform one or more activities. According to the WHO, 15% of the world's population lives with disability (2010 estimates). This number is lower than IBGE estimates of the same year, indicate that approximately 23.9% of the Brazil's population. Race is a social construction used to distinguish people in terms of one or more physical marks, among them color. Social inequality is the phenomenon that differentiates among people in the same society. As an aggravation of this whole scenario, in this year of 2020, the COVID-19 pandemic, caused by the SARS-CoV-2, with social, economic and health impacts unprecedented. The estimate of infected and dead impact directly the health systems, in the exposure populations, vulnerable groups and the financial system. People mental health in confinement times, illness risk and death fear, access to essential goods such as food, medicines and transportation. In addition, the need for actions to contain social mobility such as isolation and quarantine, as well as the speed and urgency of testing medicines and vaccines. In mathematical and statistical terms, we intend to describe in this work relations between COVID-19 and different social inequality factors in moments before, during and after this pandemic.

Topology

First session (Thursday afternoon)

15:00 - 15:20

When is the beginning the end?

Joel Mitchell, University of Birmingham
j.s.mitchell@bham.ac.uk

Let $f\colon X \to X$ be a continuous map on a compact metric space X and let α_f, ω_f, and ICT_f denote the set of α-limit sets, ω-limit sets, and nonempty closed internally chain transitive sets respectively. α- and ω- limit sets may be viewed as the beginnings and ends of orbit sequences. We show that if the map f has shadowing then every element of ICT_f can be approximated (to any prescribed accuracy) by both the α-limit set and the ω-limit set of a full-trajectory. In particular this means that the presence of shadowing guarantees that $\overline{\alpha_f} = \overline{\omega_f} = ICT_f$ (where the closures are taken with respect to the Hausdorff topology on the space of compact sets). We progress by introducing a property which characterises when all beginnings are ends of all beginnings, and all ends, beginnings of all ends.

Some of this work is joint with Chris Good and Jonathan Meddaugh.

15:20 - 15:40

The GKT conjecture for discrete decomposition spaces

Wilson Forero, Universitat Autònoma de Barcelona
wforero@mat.uab.cat

The incidence algebra of a locally finite poset is an important construction in algebraic combinatorics, with applications to many fields of mathematics, most notably Möbius inversion. Recently, Gálvez, Kock, and Tonks generalised this to a general homotopical framework through the notion of decomposition spaces, certain simplicial ∞-groupoids. They constructed a kind decomposition space of all Möbius intervals and conjectured that it is universal in a certain sense. In this talk we sketch a proof of the conjecture in the case of discrete decomposition spaces.

15:40 - 16:00

An introduction to knot homology theories

Jorge Becerra, Groningen Rijksuniversiteit
j.becerra@rug.nl

The Alexander polynomial $\Delta_K(t)$ and the Jones polynomial $J_K(t)$ are two classical and powerful knot invariants. Just like with the genus and the singular homology groups, one would like to upgrade these polynomials to (bi)graded groups such that the polynomials can be recovered by taking some (graded) Euler characteristic. This process is usually called *categorification*.

Such graded groups indeed exist, and they are called *knot Floer homology* $\widehat{HFK}(K)$ and *Khovanov homology* $Kh(K)$, respectively. These groups retain more information about the knots than the polynomials in the sense that they strengthen some of their properties: for instance whereas the breath of the Alexander polynomial gives a lower bound for the genus of a knot, $g(K) \geq \frac{1}{2}\text{breath}(\Delta_K(t))$, knot Floer homology detects the genus of a knot. Furthermore, they also have functorial properties: if $\Sigma \subseteq S^3 \times [0,1]$ is a cobordism between knots K_1 and K_2, then there is an induced map $Kh(\Sigma)\colon Kh(K_1) \to Kh(K_2)$.

The aim of this talk is to give a short introduction to these two theories, explain why they deserve to be called *homology theories* (just like in algebraic topology) and show why they are stronger invariants than the celebrated Alexander and Jones polynomials.

16:00 - 16:20

Model categories and homotopy theories

Daniel Miguel, Universidad de La Rioja
danicortijo13@gmail.com

Model categories are a category theoretic tool defined by Daniel Quillen with the aim of generalizing the homotopy theory built for topological spaces. In the talk, we give their definition and we study them, as we did in a joint work with Enrique Arrondo. It is almost inmediate that we can define analogues of well-known notions such as cylinder spaces, path spaces and homotopies. We use these tools to build a homotopy theory. Finally we give some examples of different model structures over well-known categories, such as the expected category of topological spaces and the promising category of chain complexes of modules over a ring. Concerning the second one, we are willing to study its applications in the context of spectral sequences and spectral systems, together with Ana Romero and Andrea Guidolin. In particular, its behaviour regarding parametrizations (and consequently persistent homology), as well as related model structures, like the one for the category of filtered chain complexes.

16:20 - 16:40

Distribution functions and probability measures on linearly ordered topological spaces

José F. Gálvez-Rodríguez , Universidad de Almería
jgr409@ual.es

In this work we describe a theory of a cumulative distribution function (in short, cdf) on a separable linearly ordered topological space (LOTS) from a probability measure defined in this space. This function can be extended to the Dedekind-MacNeille completion of the space where it does make sense to define the pseudo-inverse. Moreover, we study the properties of both functions (the cdf and the pseudo-inverse) and get results that are similar to those which are well-known in the classical case. For example, the pseudo-inverse of a cdf allows us to generate samples of a distribution and give us the chance to calculate integrals with respect to the related probability measure. Finally, we give some conditions such that there is an equivalence between probability measures and distribution functions defined on a separable LOTS, like it happens in the classical case. What is more, we prove that the pseudo-inverse of the cumulative distribution function is univocally related to a probability measure. From this theory, some applications have arisen, such as a goodness-of-fit test.

This is joint work with Miguel A. Sánchez-Granero.

16:40 - 17:00

Induced A_∞-structures

Javier Aguilar, University of Kent
ja683@kent.ac.uk

An A_∞-algebra A is a module over a ring equipped with a family of "multiplications" $m_n \colon A^{\otimes n} \to A$ satisfying the relation

$$\sum_{r+s+t=n} (-1)^{rs+t} m_{r+1+t}(1^{\otimes r} \otimes m_s \otimes 1^{\otimes s}) = 0$$

for all possible values of n. When $m_i = 0$ for $i \neq 2$, this relation tells us that A is an ordinary associative algebra with multiplication m_2.

We will present how this structure naturally arises in algebra and topology and discuss some examples.

Posters

Biarchetype analysis: definition and application to sports analysis

Aleix Alcacer Sales, Universitat Jaume I
aalcacer@uji.es

We propose a new statistical methodology called biarchetype analysis (or biAA) whose purpose is to extract extreme cases of a data set, as all the archetypal analysis techniques. But unlike the previous techniques, biarchetype analysis allows the extraction of extreme cases from both the observations and the variables. This is joint work with Irene Epifanio.

First, a detailed definition of the biarchetype analysis is introduced and a numerical method has even been proposed to solve it. Next, biAA has been implemented in the R language and a package has been created for easier use. Finally, biAA has been applied to a sports analysis problem, where the biAA has allowed us to discover hidden patterns in the data. Specifically, it has been applied to a data set that contains metrics of NBA players.

The automorphism group of k-uniform hypergraphon

Nawaf Alsowait, University of East Anglia
n.alsowait@uea.ac.uk

We study the automorphism group of k-uniform hypergraphon. We hope to find a natural way to extend the notion of k-uniform hypergraph automorphism to k-uniform hypergraphon. We would like to define what it means for a hypergraphon to be pure and to study the purification of k-uniform hypergraphons. Our aim is then to prove that the automorphism group of k-uniform hypergraphon is compact.

Giving a model structure to the category of algebras over any operad in unstable global homotopy theory

Miguel Barrero Santamaría, Universität Bonn
miguelbarrero7@hotmail.es

An operad is an object which consists of a space of operations of arity n for each natural number together with a unit and a composition map. An algebra over the operad is a concrete realization of these operations on a space, satisfying various commutativity and associativity properties given by the operad.

Equivariant homotopy theory studies spaces which have a continuous action of a given group. Global homotopy theory studies instead spaces which have simultaneous and compatible actions by all compact Lie groups. One possible model for global homotopy theory is orthogonal spaces and global equivalences.

In this poster we will introduce these concepts, and then we will give for any operad on orthogonal spaces the structure of a model category to the algebras over the operad. This is in contrast to the situation in most other settings, where to obtain such a model structure the operad needs to satisfy some cofibrancy or freeness conditions.

Quasi-greedy bases for sequences with gaps and Bidemocracy

Pablo M. Berná, Universidad CEU San Pablo
pablo.bernalarrosa@ceu.es

In this poster we present recent results obtained in the field of Greedy Approximation Theory in Banach spaces. Concretely, we study the recent notion of quasi-greedy bases for sequences with gaps introduced by T. Oikhberg and, moreover, we show the connection between quasi-greediness and bidemocracy. The results that we present are in two works with M. Berasategui (U. de Buenos Aires, Argentina) and S. Lasalle (U. de San Andrés, Argentina).

Protector control via actuator and spatial attributes in a system modeled by 3D cellular automata

Mohamed Byari, GAT Faculty of Sciences and Techniques, Tangier
mohamedbyari@gmail.com

In this work, we propose an approach to control dynamic systems modeled by Cellular Automata using the notions of actuators and spatial attributes. More precisely, we have defined an attribute as a spatial characteristic that influences the dynamic behavior of the system. While actuators are the intermediaries between a system and its environment, they serve to excite the system, which leads us to study the notion of controllability via its structures. We propose a control that aims at minimizing the normalized Hamming distance between the final state and the desired state of the Cellular Automata by using actuators to excite the spatial attributes. Besides, we consider as an application case the control of forest fires, modeled by a 3D CA, and we simulate different control strategies. In this model, we use a 3D LIDAR scanner for the input spatial data.

Shrinkage for robust multivariate control charts

Elisa Cabana Garceran del Vall, IMDEA Networks Institute
elisa.cabana@imdea.org

A robust multivariate quality control technique for individual observations is proposed, based on the robust reweighted shrinkage estimators. A simulation study is done to check the performance and compare the method with the classical Hotelling approach, and the robust alternative based on the reweighted minimum covariance determinant estimator. The results show the appropriateness of the method even when the dimension or the Phase I contamination are high, with both independent and correlated variables, showing additional advantages about computational efficiency. The approach is illustrated with two real data-set examples from production processes.

Temporal patterns for pilchard captures in the Mediterranean Sea

Gabriel Calvo, Universitat de València
gabriel.calvo@uv.es

Population dynamics of small pelagic fish species could be strongly influenced by the overfishing, often in combination with environmental fluctuations and the global climate change process. In the Mediterranean Sea, the European sardine (Sardina pilchardus) is one of the most commercial species showing high over-exploitation rates over the last years.

Within this context, we analyse European sardine landings from 1970 to 2014 by countries in the Mediterranean Sea, from both the artisanal and the industrial fisheries. The statistical analysis is based on the Bayesian linear mixed-effects model and the shared-parameter model framework to joint modelling longitudinal data. This approach builds a relationship of association between the longitudinal process of the industrial fisheries and that of the artisanal fisheries, through the random effects.

We compare two different models, with and without serial correlation (i.e., a joint mixed linear model and an autoregressive joint longitudinal model), by means of the Bayes factor. This expression is hardly ever analytically tractable. For this reason, we approximate it through the harmonic mean. This is joint work with Carmen Armero, Maria Grazia Pennino and Luigi Spezia.

An improved approach for coloring graphs with projection algorithms

Rubén Campoy, Universitat de València
ruben.campoy@uv.es

Projection algorithms are powerful tools for finding common points in a collection of sets. The convergence of these algorithms is guaranteed when the sets are convex. Despite a lack of convergence results, one of these methods, namely, the Douglas–Rachford (DR) algorithm, has received much attention due to its good performance in nonconvex scenarios, especially those of combinatorial nature. We shall concern on the graph vertex-coloring problem, whose goal is to find a coloring of the vertices so that all adjacent vertex pairs have different colors. This problem has already been successfully tackled by the DR, when the problem is cast as a feasibility problem on binary indicator variables. In this talk, we consider a different formulation, which is based on semidefinite programming. The much improved performance of the DR algorithm with this new approach is demonstrated through various numerical experiments.

This is a joint work with F. J. Aragón Artacho and V. Elser.

A realization problem of groups in topology

Pedro José Chocano Feito, Universidad Complutense de Madrid
pedrocho@ucm.es

The problem of realizing groups as groups of automorphisms is a classical one in mathematics. Namely, given a group G and a category $\mathcal{C}$, is there an object X in $\mathcal{C}$ such that the group of automorphisms of X is isomorphic to G? During the last five decades the interest grew up in the pointed homotopical category for CW-complexes. In this poster, we present a complete answer for the topological category (Top), homotopical category ($HTop$) and the pointed versions (Top_* and $HTop_*$). The topological spaces that we use to solve the problem are Alexandroff spaces, they are not CW-complexes but are related.

This is joint work with M. A. Morón and F. R. Ruiz del Portal.

Hybrid methods for reaction-diffusion systems

Laia Domingo Colomer, ICMAT
ldomingoc@gmail.com

Mathematical models are often used to describe physical and biological systems. Due to their inherent complexity, choosing an adequate modelling framework for such systems is a difficult task. Markov stochastic processes are current models used to describe the evolution of particle systems with great accuracy. However, as the basic simulation algorithm (Gillespieor stochastic simulation algorithm) involves computing each individual event,the computational cost is often unfeasible. On the other hand, one could study onlythe evolution of the mean-field limit of the system variables, but at cost of neglecting important properties of the system's associated noise. The aim of this work is to describe a methodology that balances efficiency and accuracy.

In this project we design a new approach of an hybrid method and implement it in a couple of reaction-diffusion systems which model biological processes. We prove that the method is numerically much more efficient than conventional stochastic processes algorithms, but still preserves the stochastic properties of the system. Moreover, the method is easier to implement in higher spatial dimensions than conventional methods.

A new Bombieri-type inequality

Ujué Etayo, Technische Universität Graz
etayo@math.tugraz.at

In this poster we recall the reader the famous Bombieri inequality, which relates products of norms of polynomials. We present a new Bombieri-type inequality for univariate polynomials with complex coefficients that is sharp. We sketch the proof, that consists on a beautiful mixture of tools coming from potential theory (logarithmic energy minimizers), numerical analysis (small-condition number polynomials), and number theory.

Hybrid Routh reduction for time-dependent Lagrangian systems

María Emma Eyrea Irazú, CONICET - Universidad Nacional de La Plata
maemma@mate.unlp.edu.ar

In this poster, we discuss Routh reduction for hybrid time-dependent mechanical systems with a cyclic coordinate. We give general conditions on whether it is possible to reduce by symmetries a hybrid time-dependent Lagrangian system extending and unifying previous results for continuous-time systems. In particular, we will study the case of Lagrangian hybrid systems where the switching surface involves time and we will construct a Routh funtion associated with this problem. Finally, we illustrate the applicability of the method using the example of a billiard with moving walls. This is a join work with Leonardo Colombo and Eduardo García-Toraño Andrés.

Towards a database of isogeny graphs

Enric Florit Zacarías, Universitat de Barcelona
efz1005@gmail.com

In number theory, it is often productive to gather arithmetic data in order to conjecture new results and discover unknown behaviour. The most notable modern case of this is the LMFDB, which contains lots of information on arithmetically interesting objects such as fields, algebraic curves and modular functions. Despite such a large collection of data, the isogeny-based cryptography community still lacks a range of examples of supersingular isogeny graphs. This work is a first attempt at generating these examples for genus 1, which involves exploring elliptic curve isogenies and computing some of their graph invariants.

Maker–Breaker total domination games on cubic graphs

Jovana Forcan, University of Novi Sad
dmi.jovana.jankovic@student.pmf.uns.ac.rs

We study Maker–Breaker total domination game played by two players, Dominator and Staller on the connected cubic graphs.

In the Maker–Breaker total domination game on a given graph G, two players take turns in claiming previously unclaimed vertices of G. Dominator wins if he can claim a total dominating set. Staller wins if she manages to claim an open neighbourhood of a vertex. The game is a variant of well-known Maker–Breaker games, in which Staller plays the role of Maker and Dominator plays the role of Breaker. Motivated by the related problem of Gledel, Henning, Iršič, and Klavžar, for certain graphs on $n \geq 6$ vertices, we give the characterization on those which are Dominator's win and those which are Staller's win.

This is joint work with Mirjana Mikalački.

Statistics of a family of piecewise linear maps

Logan Fox, Portland State University
logfox@pdx.edu

We study statistical properties of the truncated flat spot map $f_t : [0,1) \to [0,1)$ defined by

$$f_t(x) = \begin{cases} 2x \mod 1 & \text{if } \frac{t}{2} \le x \le \frac{t+1}{2}, \\ t & \text{otherwise.} \end{cases}$$

In particular, we investigate whether, for large n, the deviations $S_n(t, x_0) = \sum_{i=0}^{n-1} \left(f_t^{\circ i}(x_0) - \frac{1}{2}\right)$ upon rescaling satisfy a Q-Gaussian distribution if x_0 and t are both independently and uniformly distributed on the unit circle. This was motivated by the fact that if f_t is the rotation by t, then it has been found that the rescaled deviations are distributed as a Q-Gaussian with $Q = 2$ (a Cauchy distribution). This is the only case where a non-trivial (i.e., $Q \neq 1$) Q-Gaussian has been analytically established in a conservative dynamical system.

We prove that for the family considered here, $\lim_{n\to\infty} S_n/n$ converges to a random variable with a curious distribution which is clearly not a Q-Gaussian. However, the tail of the distribution is very reminiscent of a Q-Gaussian with $Q \approx 0.7$. This work was completed jointly with J. J. P. Veerman and Peter J. Oberly.

Non-equilibrium thermodynamics of RNA-RNA interactions underlying gene expression programs

Lucas Goiriz, I2SysBio (UV - CSIC)
lugoibel@etsiamn.upv.es

Thermodynamic descriptions are powerful tools to formally study complex gene expression programs evolved in living cells on the basis of macromolecular interactions. Whilst transcriptional regulations are often modeled in the equilibrium, other interactions that occur in the cell follow a more complex pattern. Here, we adopt a non-equilibrium thermodynamic scheme to explain RNA-RNA interactions. We determine the energy landscape associated with such an interaction at the base-pair resolution, and we present a novel scaling law for expression prediction that depends on different free energies characterizing that landscape. Then, we show that modern experimental data on a classical RNA-based regulation system are better explained by this thermodynamic description in non-equilibrium. Overall, these results contribute to better comprehend the kinetics of post-transcriptional regulations and, more broadly, the functional consequences of processes out of the equilibrium in biology.

The Eilenberg-Mazur swindle

Lucien Grillet, Université de Rennes 1
lucien.grillet@univ-rennes1.fr

This poster presents the idea of the Eilenberg-Mazur swindle, an algebraic trick that can be used to show that some operation does not have inverses. This trick is often used as a joke to provide an false proof of the equality $1 = 0$. It involves an infinite construction and is used in a visual way on this poster to show that the operation of concatenation of knots does not have inverse (one cannot create the "inverse knot" of some existing knot).

Some considerations about the regularity needed for such constructions are briefly discussed.

Discounted optimal stopping of a Brownian bridge, with application to American options under pinning

Abel Guada, Universidad Carlos III de Madrid
aguada@est-econ.uc3m.es

Mathematically, the execution of an American-style financial derivative is commonly reduced to solving an optimal stopping problem. Breaking the general assumption that the knowledge of the holder is restricted to the price history of the underlying asset, we allow for the disclosure of future information about the terminal price of the asset by modeling it as a Brownian bridge. This model may be used under special market conditions, in particular we focus on what in the literature is known as the "pinning effect", that is, when the price of the asset approaches the strike price of a highly-traded option close to its expiration date. Our main mathematical contribution is in characterizing the solution to the optimal stopping problem when the gain function includes the discount factor. We show how to numerically compute the solution and we analyze the effect of the volatility estimation on the strategy by computing the confidence curves around the optimal stopping boundary. Finally, we compare our method with the optimal exercise time based on a geometric Brownian motion by using real data exhibiting pinning.

This is a joint work with Bernardo D'Auria and Eduardo García-Portugués, from the Universidad Carlos III de Madrid.

Crossing limit cycles for piecewise linear differential centers separated by a reducible cubic curve

Jeidy Jimenez, Universidade Federal do Oeste da Bahia
jeidy.ruiz@ufob.edu.br

As for the general planar differential systems one of the main problems for the piecewise linear differential systems is to determine the existence and the maximum number of crossing limits cycles that these systems can exhibit. But in general to provide a sharp upper bound on the number of crossing limit cycles is a very difficult problem. In this work we study the existence of crossing limit cycles and their distribution for piecewise linear differential systems formed by linear differential centers and separated by a reducible cubic curve, formed either by a circle and a straight line, or by a parabola and a straight line.

This is joint work with Jaume Llibre and João C. Medrado.

On statistical convergence and Strong Cesàro convergence by moduli

María del Carmen Listán García, Universidad de Cádiz
mariadelcarmen.listan@uca.es

In this work we will establish a result by Connor in the frame of the statistical convergence and the strong Cesàro convergence defined by a modulus function f. Namely, for any modulus function f, we will prove that a f-strong Cesàro convergent sequence is always f-statistically convergent. The converse of this result is not true even for bounded sequences. We will characterize analytically the modulus functions f for which the converse is true for bounded sequences. We will prove that these modulus functions are those for which the statistically convergent sequences are f-statistically convergent, that is, we show that Connor's result is sharp in this sense.

This is a join work with Fernando León Saavedra, Francisco Javier Pérez Fernández and María Pilar Romero de la Rosa

---

Explicit description of a family of well conditioned polynomials

Fátima Lizarte, Universidad de Cantabria
fatima.lizarte@unican.es

In 1993, Shub and Smale posed the problem of finding a sequence of univariate polynomials $\mathcal{P}_N$ of degree N with condition number (a quantity associated with the zeros of a polynomial that encodes how sensitive these zeros are to perturbations of its coefficients) bounded above by N. After numerous unsuccesful attempts from different authors, for the first time, such a sequence is described by Beltrán, Etayo, Marzo and Ortega-Cerdà and satisfies that the condition number of the Nth polynomial is smaller that C times $\sqrt{N}$, where C is an unknown constant. In this work, we explicitly optimize this constant for univariate polynomials of degree $N = 4M^2$, with $M \geqslant 7$ a integer number. This offers an answer to the Shub and Smale problem with a completely explicit value for polynomials of a certain degree.

This is a joint work with Carlos Beltrán.

Local asymptotic normality for generalized panel bilinear processes

Aziz Lmakri, Université Abdelmalek Essaadi
lmakriaziz@gmail.com

The aim of this poster is to propose parametric and non-parametric (locally and asymptotically) optimal tests (in the Hájek and Le Cam senses) for the problem of detecting dependence in the class of panel bilinear models. For this purpose, the *local asymptotic normality* (LAN) property is established in order to construct this procedures. Using Le Cam approach, we extracted a locally asymptotically valid pseudo-Gaussian test. The efficiency properties of the proposed procedures are investigated by a derivation of their asymptotic relative efficiencies with respect to the corresponding pseudo-Gaussian test. Small-sample performances under several types of densities are investigated via simulations.

Feedback effect in mathematics problem-solving and reading comprehension in pre-service teachers

Emilia López-Iñesta, Universitat de València
emilia.lopez@uv.es

The skills in mathematical problem-solving and reading comprehension have been studied in numerous investigations. This article presents preliminary results of a pilot experiment in which future primary school teachers have to solve arithmetic problems that appear in primary school textbooks related to the use of fractions through a technological environment. The main objective of the experiment, in addition to assessing the knowledge of future teachers, is to measure the performance of students based on the type of feedback received after answering multiple-choice questions. The data collected after carrying out this preliminary experiment allows us to verify the positive impact of using messages with success-oriented feedback compared to the use of only correct or error messages. Besides that, we present a methodology to use the time measurement provided by the technological environment we use as a proxy to determine the arithmetic word problems complexity through the student reading comprehension.

Sobolev orthogonal polynomials: Eigenvalue problem

Juan Francisco Mañas Mañas, Universidad de Almería
jmm939@ual.es

The classical continuous hypergeometric polynomials can be defined as the polynomial solutions to the hypergeometric differential equation $\sigma(x)y''(x) + \tau(x)y'(x) = \lambda_n y(x)$, where $\sigma(x)$ and $\tau(x)$ are polynomials and λ_n are the corresponding eigenvalues of this differential equation.

We denote by $\{q_n(x)\}_{n\geq 0}$ the sequence of Sobolev orthogonal polynomials with respect to the inner product

$$(f,g)_S = \int f(x)g(x)d\mu + Mf^{(j)}(c)g^{(j)}(c) + Nf^{(k)}(d)g^{(k)}(d),$$

with $j,k \in \mathbb{N} \cup \{0\}$, $c,d \in \mathbb{R}$, $M,N > 0$ and μ is a classical continuous measure with support on the real line (Jacobi, Laguerre or Hermite). Several author proved that the polynomials $q_n(x)$ are eigenfunctions of other differential equation and **obtaining the asymptotic behavior of the corresponding eigenvalues is the principal goal of this poster**. We have proved that this behavior is different from the one of λ_n and we summarize the results of several papers. As far as we know it is the first time in the framework of Sobolev orthogonality that the asymptotic behavior of the eigenvalues is studied.

This is joint work with Lance L. Littlejohn (Baylor University), Juan J. Moreno-Balcázar (Universidad de Almería) and Richard Wellman (Colorado College).

Linkable attribute-based signatures

Ramiro Martínez, Universitat Politècnica de Catalunya
ramiro.martinez@upc.edu

E-Voting requires very specific notions of security. On the one hand, the origin of a casted vote has to remain private. On the other hand, only votes coming from eligible voters should be tallied. These seemingly contradictory properties are handled via Zero-Knowledge Proofs of Knowledge (ZKPoK) that allow proving knowledge of a secret satisfying some property without revealing any additional information. As voting data is specially sensitive we support them with post-quantum assumptions.

Attribute-Based Signatures (ABS), a special kind of electronic signatures that cannot be traced back to the signer identity, are designed to guarantee that the signer has some attributes satisfying certain conditions (e.g., citizenship and at least voting age, without revealing further details).

This preserves the anonymity of the voter while ensuring that every casted vote comes from someone with the right to vote. However the desired anonymity of the votes now implies that a voter can cast multiple votes without anyone noticing.

In this poster we show how we can wrap ABS with a linking algorithm that tells us if two signatures were created by the same voter or not. We provide a general construction for these Linkable Attribute-Based Signatures, formally prove its security and show how it can be instantiated from lattice-based primitives designing the required ZKPoK.

Nonlinear dynamics of the scattering of helium atoms off a vibrating corrugated copper surface

Javier Montes, ICMAT and Universidad Autónoma de Madrid
javier.montesm@uam.es

The system under study here is a realistic model for the chaotic scattering of helium atoms off a copper corrugated surface. If the temperature of the surface is 0 K, we can describe the system with a two degree of freedom (2-dof) model describing the trajectories of the He in a $(x-z)$ plane. The homoclinic tangle generated by the two manifolds (stable and unstable) emanating from the principal unstable periodic orbit, consisting of the helium atom traveling parallel but very far from the surface, completely determines the entire scattering dynamics.

When the temperature is (moderately) above 0 K the surface vibrates (harmonically) and the dimensionality of the system increases, but the principal unstable periodic orbit remains. The results depend now of an additional parameter: the phase when the incident atom encounters the surface, which determines that the atom gains or loses energy. In phase space, the previous manifolds turn into normally hyperbolic invariant manifolds (NHIM), for which we have an approximate model. Moreover, the tool known as 'scattering map' developed by Seara, Deshalms and de la Llave can also be applied to the study of this increased dimensionality system.

Stability of points of the rank-one non-convex optimization problem

María Mora Jiménez, Universitat Politècnica de València
mamoji7@posgrado.upv.es

A lot of today's physical problems require techniques that involve the resolution of arbitrarily large systems. A popular numerical approach in the engineering community is the so-called Proper Generalized Decomposition PGD algorithm. It is based in a particular tensor decomposition and it is also related with the separation of variables technique for Partial Differential

Equations. One of the problems that we encounter within the use of the PGD procedure is the resolution, at each step of the algorithm, of the non-convex optimization problem

$$\min_{x \in \mathcal{S}_1} \|A\mathbf{x} - \mathbf{f}\|_2, \tag{P}$$

where $\mathcal{S}_1$ is the set of rank-one vectors. To solve this, we normally use the Alternating Least Square (ALS) algorithm, but this algorithm provides us one of the several critical points of the problem (P). To study the behaviour of these points we reformulate (P) by using the geometry of the manifold of tensors of fixed rank-one in order to construct equivalent formulation to (P), by constructing a vector field $\mathbf{X}$ related with (P), and characterising the critical points of $\mathbf{X}$ by using the associated Jacobian $D\mathbf{X}$ at that points. This is joint work with Antonio Falcó Montesinos, from CEU-UCH University.

Admissible $\mathfrak{sl}_2$-induced modules in the minimal orbit

Oscar Armando Hernández Morales, Universidade de São Paulo
oscarhm@ime.usp.br

In the recent paper (2020) we described a new family of relaxed highest weight representations of an admissible affine vertex algebra $V_k(\mathfrak{g})$ of type A in the minimal nilpotent orbit. These representations are simple quotients of representations of the affine Kac-Moody algebra $\widehat{\mathfrak{g}}$ induced from $\mathfrak{g}$-modules. In particular, we described all $V_k(\mathfrak{g})$-modules induced from $\mathfrak{sl}_2$-modules in the minimal nilpotent orbit for $\mathfrak{g} = \mathfrak{sl}_{n+1}(\mathbb{C})$.

This is joint work with Vyacheslav Futorny and Luis Enrique Ramirez.

A note on Möbius structures on surfaces

Rodrigo Morón Sanz, Universidad de Granada
ruyman@correo.ugr.es

It is well-known that conformal geometry for Riemann surfaces carries no local information. A Möbius structure is an additional structure on such surfaces which, in some sense, remedies this fact. The Möbius structures play the role of the Schouten tensor for greater dimensions. In this talk, we introduce a relationship between Möbius structures and Lorentzian geometry. Namely, every Möbius structure can be realized by means of Weingarten endomorphisms of certain spacelike immersions of the Riemann surface into a 4-dimensional Lorentzian manifold.

Numerical simulation of electromagnetic fields for geophysical exploration

Marco Oliva-Gutierrez, Universitat Politècnica de Catalunya
marco.oliva@upc.edu

We are working on developing the numerical solution of a new electromagnetic (EM) model, which considers both diffusion and absorption phenomena in a single time-dependent PDE, defined by the Helmholtz equation for Electric Field. Our objective is to simulate a particular capacitive phenomenon that occurs when an Electric field falls upon a media, and the energy is stored for a short time. The Induced Polarization phenomena.

Besides the classical EM parameters such as conductivity, our model incorporates four new variables where a couple of them are obtained by the solution of a simple inverse problem. This procedure is part of the main solution scheme based on a novel class of finite elements whose degrees of freedom are defined in the elements' edges rather than at the nodes and bringing valuable properties in the computation of EM fields.

We aim to respond to questions related first to geophysics if the Induced Polarization could be a valuable parameter to improve geophysical systems' characterization. On the other hand, on the numerical analysis of the PDE's own nature if it can give better results in accuracy, stability, and computing time than different methodologies based on finite differences.

Optimal pseudo-Gaussian test for linear mixed models

Yassine Ou larbi, Faculté des Sciences et Techniques de Tanger
yassineoularbi2@gmail.com

Linear mixed models are widely used in many applications to model the correlated data. One question that frequently arises when we fit a parametric mixed model is the identification of fixed (assumed to be constant in the population) and random (those that vary from one individual to another) parameters. From a statistical point of view, this problem can be formulated as a hypothesis test, in which we test if the variances of a subset of random effects are zero, and can be treated with a test likelihood ratio. Usually the LRT (Likelihood Ratio Test) can be implemented based on the assumption that the random effects and errors are independent and normally distributed, however, this hypothesis is not always satisfied in practical situations. In this work, we propose a new locally and asymptotically optimal test statistic in the sense of Le Cam, based on the asymptotic local normality. In particular, we show that the limit law is independent of the normality of random effects. We justify the performance of our test statistic on simulated data.

This is joint work with Abdelhadi Akharif, Rachid El Halimi & Amal Mellouk.

A two-level method based on multiplicative Schwarz smoothers for isogeometric discretizations

Álvaro Pé de la Riva, Universidad de Zaragoza
apedelariva@unizar.es

Nowadays, the search of fast solvers for isogeometric discretizations is receiving a lot of attention. A desired property of these solvers is their robustness with respect to both the polinomial degree p and the mesh size h. In this work, we propose a two-level method such that a discretization of order p is considered in the fine level whereas a low-order scheme ($p_{low} = 1$ or $p_{low} = 2$) is used at the coarse level which is obtained by standard coarsening (doubling the mesh size). At the first level, only one iteration of an overlapping multiplicative Schwarz method is applied, in the way that the block size of such block smoother is chosen according to the order of the fine discretization. This choice is supported by a local Fourier analysis. At the second level, the problem can be solved exactly with any given strategy. However, it is also possible to get an approximation of the solution at this level by using an $h-$multigrid method.

By using this latter approach, we show that the resulting solver is efficient and robust with respect to the spline degree p.

Relative asymptotic behavior of Uvarov modified orthogonal polynomials.

Javier Alejandro Quintero Roba, Universidad Carlos III de Madrid
jaquinte@math.uc3m.es

Suppose μ is a positive Borel measure supported on $[0, \infty)$, with finite moments that satisfy a so called Carleman's condition, and such that its Radon-Nikodym derivative with respect to the Lebesgue measure is positive almost everywhere on $[0, \infty)$. If $r(x)$ is a rational function with zeros and poles on $\mathbb{C} \setminus [0, \infty)$, we denote by $r(x)d\mu(x)$ a rational modification of μ.

We obtain the relative asymptotic behavior between the orthogonal polynomials with respect to $r(x)d\mu$ and the orthogonal polynomials with respect to $d\mu$.

This is a joint work with Héctor Pijeira Cabrera from Universidad Carlos III de Madrid.

Anticipating stochastic calculus. Optimal investment strategies under insider trading

Sandra Ranilla-Cortina, Universidad Complutense de Madrid
sranilla@ucm.es

In this work we study the presence of insider information in a non-adapted version of the simple problem of portfolio optimization in a financial market.

We consider three different anticipating stochastic integration theories: the Russo-Vallois Forward, the Ayed-Kuo, and the Hitsuda-Skorokhod integrals.

We analyze a specific formulation of the insider trading problem for the bank account and for the stock. We compute the optimal portfolio, i.e, the optimal investment strategy for each case, and compare the results obtained.

The results suggest that the Ayed-Kuo and the Hitsuda-Skorokhod integrals provide a solution that seems to be counterintuitive in the financial sense, while the Russo-Vallois integral gives a financially meaningful investment strategy for this problem.

Why using topological and analytical methods in aggregation of fuzzy preferences?

Armajac Raventós Pujol, Universidad Pública de Navarra
armajac.raventos@unavarra.es

The Arrow's Impossibility Theorem states that there is no function fusing individual preferences into a social one satisfying certain properties of "*common sense*". On the contrary, in some of the fuzzy extensions of the Arrovian model, possibility arises.

We have developed a technique which has been able to prove new impossibility results in the fuzzy approach. In this poster, we will explain the fundaments of this technique and in which models we can apply it.

This technique, is based on controlling the aggregation of fuzzy preferences through some aggregation functions of dichotomic preferences. For each fuzzy aggregation function, we get a family of dichotomic aggregation functions. Studying this family, we obtain information about the initial aggregation function.

We will discuss why the fuzzy Arrovian models in which we can apply this technique are, in some sense, less fuzzy (and, in a certain manner, sometihing crisp-like). Moreover, we will expose why we should use topological and analytical methods in the fuzzy models out of the scope of our technique.

This is a joint work with María Jesús Campión and Esteban Induráin.

Ejection-collision orbits in the CPRTBP

Óscar Rodríguez, Universitat Politècnica de Catalunya and Università di Pisa
oscar.rodriguez@upc.edu

In this study we analyse the ejection orbits of the circular and planar restricted three body problem (CPRTBP). In particular we focus on the ejection-collision (EC) orbits of the CPRTBP. As it is well known, for any value of the mass parameter $\mu \in (0, 0.5]$ and sufficiently restricted Hill regions, there are exactly four EC orbits. We check their existence and extend numerically these four orbits for $\mu \in (0, 0.5]$ and for less restrictive values of the Jacobi constant.

We introduce the concept of n-ejection-collision orbits and we explore them numerically for $\mu \in (0, 1)$ and values of the Jacobi constant such that the Hill region containing the first primary is bounded and does not contain the second one.

In addition we study the evolution of the ejection orbits for bounded Hill regions (that may contain the smaller primary).

This is joint work with Mercè Ollé and Jaume Soler.

A tale of p-divisible groups

Francesco Maria Saettone, Ben-Gurion University of the Negev
saettone@post.bgu.ac.il

What is a p-divisible group? Starting from this question, the goal of this presentation is to provide a concise introduction to a basic tool in p-adic Hodge theory with familiar examples, showing some of the main applications.

John Tate's seminal 1967 paper "p-Divisible Groups" is our starting point to mention some exciting topics as the Hodge-Tate decomposition, used to study the natural action of the absolute Galois group on the Tate module. If time will permit, I will spend few words on the universal cover of a p-divisible group and its crystalline theory, which is useful to understand the proof of the classification theorem for vector bundles on the Fargues-Fontaine curve.

Ensuring learning: the role of community tutors in remote Mathematics education

Chonilo S. Saldon, Zamboanga del Norte National High School
schonilo@yahoo.com

Learning Mathematics has been disrupted in the face of COVID-19 pandemic. With the shift to remote education, ensuring continuity of learning Mathematics is of paramount interest of educationists. Community learning facilitators play the pivotal role in ensuring that learning continues. This study aims to document community tutors' experiences. Using narrative inquiry design, ten tutors were followed. Journals and follow-up interviews were the main source of qualitative data. The study revealed that tutors employed different modalities in their tutorial sessions and provided different pedagogical techniques. They described themselves as important student support in the new norms of education, supplementing the inadequacies of instructional delivery in remote learning and counselors providing emotional support to learners. The study concludes that tutors and community educators should be considered as significant and integral part of the learning support in the new norms of education, and access to them should be made available especially to those who need them the most. As an output of the study, a model of establishing a network of community tutors is suggested such that the "unreached" learners can finally be "reached".

Comparison of two composite likelihood functions for spatial generalized linear mixed models

Leila Salehi, Tarbiat Modares University
leylasalehi67@gmail.com

The spatial generalized linear mixed models are flexible models for a variety of applications, where spatially dependent and non-Gaussian random variables are observed. In such cases, maximum likelihood approaches may have slow computation or even prohibitive. Alternatively, one may consider a composite likelihood-based, which is the product of likelihoods of subsets of all data. In this article, the pairwise likelihood weighted pairwise likelihood functions for parameter estimation in spatial generalized linear mixed models are used. Then, the accuracy of the parameter estimations for these two functions is compared via a simulation study. Also, to increase the accuracy of the estimating of the model parameters, the penalized pairwise likelihood function is used. The accuracies of the estimating parameters using the penalized pairwise likelihood, pairwise likelihood and weighted pairwise likelihood functions are evaluated and compared based on the mean square error criterion.

Stochastic control applied to the optimal portfolio problem

José Salmerón, Universidad Carlos III de Madrid
joseantonio.salmeron@uc3m.es

The optimal portfolio problem is one of the best studied issues in finance. It consists of dividing the capital of an agent in a convenient way in order to maximize the expectation at the end of a given maturity. In our work, we have developed stochastic control results and we study their application to this problem when there exist agents with different levels of information. In particular, we analyze the bankruptcy case, the stochastic interest rate and the presence of

a Markov modulated process. For this examples, we compute the optimal strategy and the expected utility for an insider and an honest traders.

Multiscale modelling of nanoparticle delivery and heat transport in vascularised tumours

Tahani Mohammed Sulaiman Al Sariri, University of Glasgow
t.al-sariri.1@research.gla.ac.uk

Cancer hyperthermia therapies are based on the application of suitable magnetic fields exciting Iron Oxide nanoparticles delivered intravascularly. We aim at retaining the influence of the micro-vessels on the nanoparticle distribution and temperature maps, however, the system under consideration is intrinsically multiscale. In fact, the distance between adjacent vessels is much smaller than the average tumour size, where experimental measurements are usually performed, thus motivating a homogenization approach. We derive a new system of homogenized partial differential equations which describes blood transport, nanoparticle delivery, and heat by means of the asymptotic homogenization technique. The new model comprises a double Darcy's law for the fluid flow, and a double advection-diffusion-reaction system for the particle and heat transport (with mass, drug, and heat transport between compartments). The role of the microstructure is encoded in the coefficients of the model which are to be computed solving appropriate microscale periodic problems. According to our numerical results, the heat increases towards the center and the temperature is directly proportional to the absorption rate.

This is joint work with Raimondo Penta.

Optimal experimental design for parametric identification in electrical impedance models

Àngela Sebastià Bargues, Universidad de Castilla-La Mancha
angela160794@gmail.com

The electrical behavior of a great variety of systems can be characterized by impedance measurements, that is, the opposition that a specific system under study presents to the flow of electrical current as a function of frequency. The mathematical model used is a simplified Randles circuit, in which the parallel combination of a capacitor and a resistor describes the impedance of the simplest form of a corroding electrode interface or the electrical passive behaviour of a cell membrane. We formulate the problem of estimating parameters in the linear single input single output (SISO) system in the frequency domain using the theory of optimal experimental design analysis. In order to obtain the optimal input signals for parameter estimation, we compute approximate and exact optimal designs optimizing the determinant of the information matrix by adapting two of the most algorithms (randomized exchange algorithm REX and KL-exchange algorithm) that are routinely used nowadays.

This is joint work with Raúl Martín Martín and José Luis Polo Sanz.

Matroid polytopes, the half plane property and more

Büşra Sert, Technische Universität Dresden
buesra.sert@tu-berlin.de

Matroids have become an important tool for studying properties such as the half plane property or the determinantal representability of homogeneous multiaffine polynomials, such as hyperbolic polynomials, in the context of the *Generalized Lax Conjecture*. The conjecture states that every hyperbolicity cone is spectrahedral. Since hyperbolicity cones and spectrahedral cones are feasible sets of hyperbolic programming and semi-definite programming respectively, the conjecture implies that hyperbolic programming and semi-definite programming have the same expressive power. Choe *et al.* in 2004 showed that the support of a homogeneous, multiaffine polynomial with the half-plane property, is the set of bases of a matroid M. Note that such a polynomial with the half-plane property is hyperbolic. Their results provide a good resource to work on the conjecture, as seen for example in the work of Brändén in 2011.

In this work, we consider matroid polytopes: these are Newton polytopes of the basis generating polynomials of matroids. We show that, if the matroid polytope of a matroid M is a face of the matroid polytope of $M^{'}$, and $M^{'}$ has the half-plane property or determinantal representability, then the respective property is inherited for M. As a next step, we are working on adapting those results to the inheritance of "hyperbolicity cones are spectrahedral". This is joint work with Mario Kummer.

Best approximations and greedy algorithms

Victoria Shkapa, State University of Telecommunications
vshkapa@ukr.net

We investigates some approximate characteristics of the classes of periodic functions of one variable in the Lebesgue spaces.

We obtained exact order estimates of the best approximations, approximations by Fourier sums, the best m-term trigonometric approximations, the best orthogonal trigonometric approximations, greedy algorithms and trigonometric widths of the classes periodic functions of one variable (the classes of Weyl – Nagy type) in the Lebesgue spaces with some restrictions on parameters. We also obtained exact order estimates of the best bilinear approximations of the classes of functions of two variables generated by functions of a single variable from the same classes of periodic functions by the shifts of the argument. The fact that the order estimates of the best bilinear approximations coincide with the order estimates of the Kolmogorov widths that were obtained before was revealed during the research.

Evolution of mathematical modeling as a method of scientific cognition

Olga Shvai, Lesya Ukrainka Volyn National University
Shvai.Olga@gmail.com

Mathematical modeling is one of the main modern methods of cognition. It is widely used in all branches of scientific investigations.

We consider the historical aspects of the development of the method of mathematical modeling and point out the epistemological functions of this method.

An investigation of the historical aspects of development of the method of mathematical modeling has shown that its development was tightly connected with the development of science itself. The term "model" was introduced to mathematics in the 19th century due to the appearance of hyperbolic geometry by Nikolai Lobachevsky (1792-1856) and spherical geometry by Georg Riemann (1835-1900). Nevertheless, an application of mathematical modeling in the 19-20th centuries was accompanied by certain difficulties. It happened so because of the lack of researcher's mathematical education to describe mathematically new phenomena of science. Therefore, mathematical modeling was applied only in those branches of knowledge that have gained a high level of the development.

Goldbach's strong and weak conjectures under complex networks perspective

Pedro A. Solares H., Universitat Politècnica de València
pedsoher@doctor.upv.es

The mysterious universe of prime numbers is one of the fields of number theory that has attracted many mathematicians and amateurs for centuries. In this sense, *Goldbach's conjectures (strong and weak)* have been two of the most studied mathematical problems from the perspective of number theory and prime numbers. The weak conjecture was successfully proved in 2015 by Harald Helfgott. We analyze the formulation of both conjectures from the perspective of network science. We make a comparative study of the different topologies emerging from the corresponding complex networks. Applying the Kolmogorov-Smirnov test, we have determined that the degree distribution behaves similarly to the power-law distribution. These patterns have already been noticed when studying divisibility networks.

This is joint work with J. Alberto Conejero and Miguel A. García March

---

Cohomologies for categories of sheaves

Ana Luiza Tenorio, IME-USP
ana.tenorio@usp.br

A sheaf on a topological space Y is a functor $F\colon \mathcal{O}(Y)^{op} \to Set$ satisfying gluing properties, where $\mathcal{O}(Y)$ is the category of open subsets of Y. However, the sheaf's definition does not use the points of the topological space, so it is natural to consider sheaves on *locales* H, the objects studied in point-free topology. This concept is already established, in particular, it is know that the category $Sh(H)$ of sheaves on H is equivalent to the category of H-sets, where an object in this category is a pair (X, δ), with X a set and $\delta\colon X \times X \to H$ a function such that $\delta(x, y) = \delta(y, x)$ and $\delta(x, y) \wedge \delta(y, z) \leq \delta(x, z)$ and it has suitable correspondent morphisms. Furthermore, for any small category $\mathcal{C}$ with a proper cover notion, called Grothendieck Topology, it is possible to define Grothendieck Toposes, a generalization of sheaves that originated Étale Cohomology.

In this poster, we present these classic notions of sheaves, introduce an in-progress work that considers sheaves on commutative *quantales* Q (a generalization of locales), and explain the connections between the category $Sh(Q)$ and the category of Q-sets - for an adapted version of Q-set. Additionally, the Grothendieck Topology definition can be modified to generalize the sheaves on Q, thus we will discuss cohomology theories for these new sheaf categories, guided by its internal logic and the usual Sheaf Cohomology.

Patchworking real algebraic curves with prescribed number of connected components

Cédric Le Texier, Universitetet i Oslo
cedricle@math.uio.no

In 1997, Haas gave a necessary and sufficient condition to obtain M-curves (which are real algebraic curves reaching Harnack-Klein's bound on the number of connected components in its real part) via combinatorial patchworking. We introduce several new combinatorial conditions in order to obtain a real curve with prescribed number of connected components, in terms of twisted edges on a tropical curve.

We start by giving an equivalent condition for (M-1)-curves, followed by an equivalent condition for (M-2)-curves of dividing type (where dividing means that the real part of the curve disconnects its complex part). From these two cases, we build a sufficient condition for any prescribed number of connected components; if we restrict to curves of dividing type, this last condition will also be necessary.

Investigation of solvability of nonlocal problem for hyperbolic equation

Kirichek Vitaliya, Samara University
Vitalya29@gmail.com

In this work we consider a hyperbolic equation with nonlocal conditions which are integral conditions of the 2nd kind [1] with nonintegral terms which represent traces of required solution on the boundary. The choice of a method for studying nonlocal problems depends on the type of integral conditions. At the moment there are the most effective methods for studying nonlocal problems: the method of auxiliary problems and the method of reduction to a loaded equation with homogeneous boundary conditions. The second of these methods is considered in this paper. To study this problem, we apply classical methods, which are used to prove the uniqueness and existence of the weak solution of the problem. We also show that the nonlocal problem and initial-boundary problem for a loaded equation are equivalent.

Estimates of norms for trigonometric polynomials of the classes of differentiable functions

Hanna Vlasyk, State University of Telecommunications, Kyiv, Ukraine
annawlasik@gmail.com

We obtained the exact order estimates for derivatives of the Dirichlet type kernels with the best choice of harmonics and to comparison of obtained results with estimates for derivatives of the Dirichlet kernels. Shown here is that the Dirichlet kernels and the Dirichlet type kernels with the best choice of harmonics differ in order. We obtained the exact order estimates of the Bernstein – Nikol'skii type inequalities for trigonometric polynomials with an arbitrary choice of harmonics.

On the Brauer group of bielliptic surfaces

Magnus Røen Vodrup, Universitetet i Bergen
magnus.vodrup@uib.no

We provide explicit generators of the torsion of the second cohomology of bielliptic surfaces, and we use this to study pullback maps between Brauer groups. Joint work with Jonas Bergstöm, Eugenia Ferrari and Sofia Tirabassi.

Mathematical modeling of the selective laser sintering of polyamide 12 - 3D printing

Hanane Yaagoubi, LAMAT, ENSET, STIS Research Center Mohammed University
hanane.yaagoubi@um5s.net.ma

3D printing is an interesting process for the rapid fabrication of three-dimensional objects. Selective sintering laser printers use a laser to fuse polyamide 12 particles using the CO2 laser. All 3D printing processes require software tools, hardware and materials. 3D printing technologies make it possible to create objects of all types, from prototypes to simple parts, passing by high-tech products, such as aircraft parts, environmentally friendly buildings, medical implants which save lives and even artificial organs made from human cells. And also in this period of covid19: innovation and 3D printing at the service of all, 3D printing very often rhymes with progress, but also with solidarity and inclusion. If it has already shown its effectiveness in the field of disability for example, in this period of pandemic, 3D printing has met several urgent needs: valves for breathing apparatus, small isolation houses, masks and others. This study focuses on the numerical study of heat transfer, melting, solidification and coalescence of polyamide 12 particles invoked by laser heating in the application to selective laser sintering, the temperature distinction between the different regions of the process causes the presence of deformations, but of this work is the highlighting of the thermal phenomenon sls, following the progress of the temperature following time.

Cooperative transportation with a team of drones

Omayra Yago Nieto, Universidad Complutense de Madrid
omayyago@ucm.es

The aim of this poster is to show how to modelize the cooperative motion of a team of quadrotors (a class of drone) carrying a heavy and rigid object, by using elastic cables. We derive the control equations for our model by using tools of variational calculus on manifolds and Lagrangian mechanics. We also propose a reduced model for the system to avoid the singularity that produces the elasticity of the cables. The reduced model is the appropriated model to study the convergence of the system to desired trajectories for the load in the transportation task. This is joint work with Leonardo Colombo.

Singular and fractal properties of functions associated with three-symbolic system of real numbers coding

Iryna Zamrii, State University of Telecommunications Kyiv
irinafraktal@gmail.com

Continuous singular and piecewise singular functions defined in terms of given polybasic three-symbolic representation of real numbers, that depends from three parameters and is a generalization of classic ternary representation of real numbers, are considered. Their local and global properties (structural, variational, extreme, differential, integral and fractal) are studied. A family of continuous functions that store a central digit in a given polybasic three-symbolic representation of real numbers, that depends from three parameters and is a generalization of classic ternary representation of real numbers, is investigated. It is proved that the set of such functions is continuous. A special role in this family has unique strictly decreasing function, called the inversor of digits. Also we thoroughly study the properties of several model representatives of countable subclasses of functions with one and two infinite levels respectively. They are piecewise singular. We found equivalent definition for them.

Fundación BBVA

DMA
DEPARTAMENT DE MATEMÀTICA APLICADA

Universitat de València

Facultat de Ciències Matemàtiques

mathematics
an Open Access Journal by MDPI

BYMAT
Bringing Young Mathematicians Together