Invited Speakers
Conférenciers invités

NICOLAS ANDRUSKIEWITSCH, Universidad Nacional de Córdoba, Argentina
Nichols algebras

Nichols algebras are graded algebras with intricate combinatorial properties that appear as fundamental invariants of Hopf algebras. There is a Nichols algebra for each solution of the quantum Yang-Baxter equation. I will overview the definition, some basic properties and open questions on Nichols algebras. Then I will discuss several classes of Nichols algebras, including:

1) Finite-dimensional Nichols algebras of diagonal type: their classification by Heckenberger, the theory of Weyl groupoids, the relation with Lie superalgebras, the determination of the defining ideal by Angiono.

2) Nichols algebras of modules over quantized enveloping algebras with Gelfand-Kirillov dimension, classified by Ufer.

3) Finite-dimensional Nichols algebras over non-abelian groups.

4) Nichols algebras over abelian groups with Gelfand-Kirillov dimension, including joint work by Angiono, Heckenberger and myself.

LIA BRONSARD, McMaster University
Droplet phase in a nonlocal isoperimetric problem under confinement

We begin with a variational model for the self-assembly of diblock copolymers under confinement, which takes the form of an isoperimetric problem which is both nonlocal and nonhomogeneous. That is, we seek minimizers in the form of characteristic functions of fixed volume. The energy consists of three competing terms, and minimizers should reduce their perimeter (as in the classical isoperimetric problem,) but also prefer spatial separation into disjoint components, which are confined by an attractive potential. We consider periodic configurations in the small volume fraction limit, in which one phase forms vanishingly small droplets in a sea of the complementary phase. Introducing a small parameter $\eta > 0$, which represents the radii of the droplets, we show that the minority phase splits into several droplets which converge to the maximum value of the confining potential, at an intermediate scale $\eta^{1/3}$. Isolating the droplets at the scale $\eta^{1/3}$ requires a fine analysis of the blown-up problem, using concentration-compactness and the regularity properties of minimizers of the nonlocal isoperimetric problem on $\mathbb{R}^3$. This is joint work with Stan Alama, Rustum Choksi and Ihsan Topaloglu.

KRZYSZTOF BURDZY, University of Washington
On number of collisions of billiard balls

In lieu of an abstract I offer a problem. Consider three billiard balls of the same radius and mass, undergoing totally elastic reflections on a billiard table with no walls (the whole plane). All three balls can be given non-zero initial velocities. What is the maximum (supremum) possible number of collisions among the three balls? The supremum is taken over all initial positions and initial velocities. I will discuss this problem and its generalization to any finite family of balls in one, two and higher dimensions. Joint work with Mauricio Duarte.

RUSTUM CHOKSI, McGill University
Geometric Variational Problems with Nonlocal Interactions: Gamow's Liquid Drop Problem and Beyond

The liquid drop (LD) model, an old problem of Gamow for the shape of atomic nuclei, has recently resurfaced within the framework of the modern calculus of variations. The problem takes the form of a nonlocal isoperimetric problem on all 3-space with nonlocal interactions of Coulombic type. In the first part of this talk, I will present the current state of the art for the existence and nonexistence of minimizers of the LD problem. I will then focus on the LD problem on a finite domain, and its relation to the Ohta-Kawasaki theory for self-assembly of diblock copolymers. I will discuss the fundamental problem of addressing the intrinsic periodicity of minimizers. In the second part of the talk, I will consider minimizers of a geometric problem based solely on competing interaction potentials of algebraic type. The problem is directly related to a wide class of self-assembly/aggregation models for interacting particle systems (eg. swarming).

MARIA CHUDNOVSKY, Princeton University
Induced Subgraphs and Coloring

What causes a graph to have high chromatic number? One reason is that the graph may contain a large set of pairwise adjacent vertices (called a "clique"), but what can be said if that is not the case? Around 1985 Andras Gayfas made three conjectures about structures that must be present in a graph with large chromatic number all of whose cliques have bounded size. Recently we proved the strongest of these conjectures, that implies the other two. In this talk we will discuss some of the proof ideas, and related problems and theorems.

JUAN DAVILA, Universidad de Chile
Finite time singularities for the harmonic map flow in 2D with values into de sphere

We study singularity formation in the harmonic map flow from a two dimensional domain into the sphere. We show that for suitable initial conditions the flow develops a type II singularity at some point in finite time, we obtain obtain the rate and profile, and we analyze the stability of this phenomeon. We also obtain obtain solutions with multiple singularities and reverse bubbling. The rate and profile of blow up were derived formally by van den Berg, Hulshof and King (2003) and proved by Raphael and Schweyer (2013) in the class of 1-corrotationally symmetric maps. This is joint work with Manuel del Pino (Universidad de Chile) and Juncheng Wei (University of British Columbia).

LUZ DE TERESA, Universidad Nacional Autónoma de México
Give me absolute control over every......

I've seen the future..., paraphrasing Leonard Cohen. But, in mathematics, Control Theory is not dead. From Linear Algebra to Theory of Numbers, from Complex to Functional Analysis, when controlling a partial differential equation you never know which area of mathematics you will use to achieve your objective. In this conference, I will try to present a panoramic on the subject illustrating some of the techniques employed in this fascinating growing area that has interest for theoretical and applied mathematicians.

YAKOV ELIASHBERG, Stanford University
Weinstein manifolds revisited

Weinstein manifolds are symplectic analogs of Stein complex manifolds. In the talk I will review old and new results, as well as open problems about their symplectic topology.

PABLO FERRARI, Universidad de Buenos Aires
Stationary solitons in the Box Ball System in Z

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The Ball Box System (BBS) is a cellular automaton introduced by Takahashi and Tatsuma in 1990 as a discrete analog of the KdV pde, a partial differential equation with many soliton solutions. In the BBS a box is placed at each integer number and can either be empty or contain a ball. A carrier with infinite capacity visit successively the boxes from left to right. The carrier picks balls from occupied boxes and leaves carried balls at empty sites. We discuss existence conditions and invariant states. The automaton has countable many conserved quantities which travel at different speeds (solitons). We show that the product measure at any density less than 1/2 is invariant. Furthermore we describe independence properties of the spatially mixing invariant measures and speed interaction of the solitons. Work in collaboration with Chi Nguyen, Leonardo Rolla and Minmin Wang.

HARALD HELFGOTT, University of Goettingen/CNRS
Voronoi, Sierpinski, Eratosthenes

We show how to carry out a sieve of Erastosthenes up to N in space $O(N^{1/3})$ and essentially linear time. This improves over the usual versions, which take space about $O(\sqrt{N})$ and essentially linear time. The algorithm – which, like the one in (Galway, 2000), is ultimately related to diophantine approximation – can also be used to factorize integers n, and thus to give the values of arithmetical functions such as the Möbius function μ and the Liouville function λ for all integers up to N.

JEREMY KAHN, Brown University
Applications and Frontiers in Surface Subgroups

In 2009 V. Markovic and the speaker proved that there are ubiquitous nearly geodesic surface subgroups in the fundamental groups of closed hyperbolic 3-manifolds. Since then there have been many attempts—and some noteworthy successes—to extend these results to other settings, including lattices in other Lie groups, nonuniform lattices, δ-hyperbolic groups, and the mapping class group. After a review of the fundamental principles and methods, I will try to describe some of the successes, some of the difficulties, and some of the applications of these kinds of results.

MATT KERR, Washington University in St. Louis
Normal functions in geometry, physics, arithmetic

Normal functions are "well-behaved" sections of a bundle of complex tori (intermediate Jacobians) associated to a period map (variation of Hodge structure). They arise from families of (homologically trivial) algebraic cycles on the fibers of a smooth proper morphism of varieties, and were first studied by Poincaré and Lefschetz for families of divisors on curves. Conversely, given a normal function, existence of such families of cycles is predicted by the Hodge Conjecture, one of the seven Millenium Problems.

A more general notion of cycles, due to Bloch and Beilinson and closely related to algebraic K-theory and motivic cohomology, leads to generalizations called "higher normal functions". Normal functions and their higher analogues often show up in unexpected places, explaining and generalizing observed arithmetic and functional properties of periods.

In this talk, we will give a brief tour of these ostensibly "well-behaved" functions' party-crashing exploits, from irrationality proofs and Apéry constants to quantum curves and Feynman amplitudes. No knowledge of algebraic cycles will be assumed.

CARLOS GUSTAVO MOREIRA, IMPA
Geometric properties of the Markov and Lagrange spectra and dynamical generalizations

The classical Markov and Lagrange spectra are sets of real numbers related to Diophantine Approximations. We will present classical and recent results on these sets involving their dynamical characterization and aspects of fractal geometry. We will also discuss natural generalizations of these spectra in the context of Dynamical Systems and Differential Geometry, and recent results related to these generalizations, in collaboration with Romaña, Cerqueira and Matheus.

ROBERT MORRIS, IMPA
Random graph processes

For the past several decades, since Erdős' 1947 lower bound on the Ramsey numbers $R(k)$, randomness has been an important and powerful tool for demonstrating the existence of counter-intuitive objects. When dealing with random objects, it is often useful to reveal the randomness gradually, rather than all at once; that is, to turn a static random object into a random process. In the 1980s and 1990s, several important techniques for studying the evolution of such processes were introduced by Bollobás, Rödl, Ruciński, Wormald, and others, and in recent years these techniques have been developed further by a number of different authors, and have been used to resolve several well-known open problems.

In this talk we will describe a few of these recent developments, focusing our attention on two or three specific examples. In particular, we will discuss the Ramsey numbers $R(3,k)$, and a problem of Pomerance about the existence in a random set of integers of a subset whose product is a square. In each case, the key to the proof is controlling the evolution of a suitably-chosen random (hyper)graph process using self-correcting martingales.

This talk is based on joint work with Paul Balister, Béla Bollobás, Gonzalo Fiz Pontiveros, Simon Griffiths and Paul Smith.

PAOLO PICCIONE, Universidade de São Paulo - Brazil
Teichmüller theory, collapse of flat manifolds and applications to the Yamabe problem

Using certain non-uniqueness results for the Yamabe problem as motivation, I will describe deformations of compact flat manifolds and orbifolds. Flat orbifolds (resp., manifolds) are quotients of Euclidean spaces by crystallographic (resp., torsion-free crystallographic) groups. I will explain the basic structure of these objects and describe the space of deformations of flat metrics on them (Teichmüller space), showing that flat manifolds can always be deformed, while flat orbifolds may be rigid. I will also describe the boundary of the moduli space; showing that limits of flat manifolds are flat orbifolds and, conversely, that every flat orbifold is the limit of flat manifolds. This is joint work with Renato Bettiol and Andrzej Derdzinski.

JILL PIPHER, Brown University
Regularity of solutions to elliptic and parabolic equations

A famous series of papers by De Giorgi, Nash and Moser showed that weak solutions to divergence form elliptic and parabolic equations are in fact continuous, and possess other important properties, even when the coefficients are merely bounded and measurable. This paved the way for the development of a theory of boundary value problems in the presence of minimal smoothness assumptions on the coefficients. Many of the interesting regimes in which answers are known arise from the classical Dirichlet problem for the Laplacian in domains with non-smooth boundaries. In this talk I will provide an overview of the progress in this subject, and describe some recent results concerning regularity of solutions to complex-coefficient equations.

JEREMY QUASTEL, University of Toronto
Asymptotic fluctuations in the KPZ universality class

The one dimensional KPZ universality class comprises random growth models, free energies of directed random polymers, and forced Burgers equations. We describe the KPZ fixed point, the invariant Markov process which governs the asymptotic fluctuations of all models in the class, and how it was discovered through the exact solution of a special discretization of the Kardar-Parisi-Zhang equation known as TASEP. Joint work with Konstantin Matetski and Daniel Remenik.

BERNARDO URIBE, Universidad del Norte
Decomposition of equivariant complex vector bundles on fixed point sets

In this talk I will show a decomposition formula for complex equivariant vector bundles once restricted to fixed point sets. This decomposition formula could be understood ar the level of representations and has very nice implications in the understanding of complex equivariant K-theory and complex equivariant bordism. The results of this talk are joint work with José Manuel Gómez and Andrés Ángel.

SHMUEL WEINBERGER, University of Chicago
The (un)reasonable (in)effectiveness of algebraic topology.

Among the great achievements of 20th century geometric topology are the classification of immersions, cobordism of manifolds the high dimensional Poincare conjecture, and surgery theory. They all involve "algebraicization" – the reduction of a geometric problem to one of algebraic topology, and then solving this. I will discuss the complexity of the solutions to these problems: how complicated are the objects that algebraic topology predicts? I hope to explain both lower bounds coming from logic and upper bounds that come from the geometric analysis of function spaces.

Based on joint work with Greg Chambers, Dominic Dotterer, Sasha Dranishnikov, Steve Ferry, Fedya Manin, and Alex Nabutovsky.

DANIEL T. WISE, McGill
The Cubical Route to Understanding Groups

Cube complexes have come to play an increasingly central role within geometric group theory, as their connection to right-angled Artin groups provides a powerful combinatorial bridge between geometry and algebra. This talk will introduce nonpositively curved cube complexes, and then describe the developments that recently culminated in the resolution of the virtual Haken conjecture for 3-manifolds, and simultaneously dramatically extended our understanding of many infinite groups.