BOOK OF ABSTRACTS

Plenary Lectures

2nd Joint Meeting Brazil-Italy in Mathematics

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Messina, Italy

Regularized block coordinate descent methods: Complexity and applications

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Block coordinate descent methods have long been an important tool in large-scale optimization. More recently, they have gained renewed attention due to the increasing prominence of machine learning applications, where scalability is a key requirement. In this talk, we present recent advances in regularized block coordinate methods for both bound-constrained and nonconvex constrained optimization. For bound-constrained problems, we describe methods based on higher-order regularization models and discuss their asymptotic convergence to pth-order stationary points. We also present worst-case complexity bounds showing that first-order stationarity with accuracy ε is attained in $\mathcal{O}(\varepsilon^{-(p+1)/p})$ iterations with respect to individual blocks and in $\mathcal{O}(\varepsilon^{-(p+1)})$ iterations with respect to the full set of variables. For general nonconvex constrained optimization, we consider block coordinate methods based on quadratic regularization. We outline their convergence properties and the associated complexity analysis, showing that a (δ, ε)-critical point can be computed within $\mathcal{O}(\varepsilon^{-2})$ iterations and function evaluations. We illustrate the practical performance of these techniques through recent applications to emerging routing problems motivated by last-mile delivery and unmanned aerial vehicle (UAV) operations.

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Blow ups in moduli problems and algebraic stacks

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Algebraic geometry studies moduli spaces, such as the Grassmann variety. In many cases, the moduli space we naturally are interested in is not proper (compact) and one wants to find a good compactification. In this talk we present two standard examples of this: the Fulton-MacPherson configuration space, and the Caporaso compactified jacobian of a nodal curve; both are based on the blow-up construction. We then informally discuss the underlying moduli stacks and other applications, including both classic results and some work in progress.

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A Riemann–Hurwitz theory for automorphism groups of curves in terms of the p-rank

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One of the central themes in the theory of algebraic curves is the interaction between birational invariants and automorphism groups. For a smooth projective curve $\mathcal{X}$ of genus $g = g(\mathcal{X}) \geq 2$ over a field of characteristic zero, the classical Riemann–Hurwitz theorem yields Hurwitz's bound

$$|\mathrm{Aut}(\mathcal{X})| \leq 84(g-1).$$

In positive characteristic, however, wild ramification may dramatically enlarge automorphism groups, suggesting that additional invariants beyond the genus are needed to understand the symmetry of algebraic curves.

A natural question is whether the p-rank can replace the genus as a complexity parameter in a positive-characteristic analogue of Hurwitz theory.

A first step toward such a theory is to understand when the p-rank becomes forced to vanish. Indeed, many of the classical examples of curves with exceptionally large automorphism groups are known to have p-rank zero. This leads to the problem of determining a function $f(g)$ such that every curve of genus g whose automorphism group exceeds $f(g)$ necessarily has p-rank zero. In the first part of the talk, we discuss results showing that, under broad hypotheses, a quadratic bound in the genus suffices. More precisely, for solvable automorphism groups, and for non-solvable groups when the genus is even, automorphism groups of size exceeding a constant multiple of g^2 force the p-rank to vanish.

The second part focuses on curves with positive p-rank. In general, no upper bound for the size of the automorphism group can depend solely on the p-rank. Nevertheless, under natural assumptions arising from the action of Sylow p-subgroups, one obtains bounds depending only on the p-rank and independent of the genus. In particular, a positive-characteristic analogue of the classical Hurwitz bound is established, showing that the automorphism group has size at most polynomial in the p-rank. Under stronger geometric assumptions, sharper bounds are obtained. These results show that the p-rank can, in suitable situations, serve as an effective measure of complexity for automorphism groups.

The proofs combine ramification theory and the geometry of algebraic curves with substantial input from finite group theory. The Hurwitz and Deuring–Shafarevich formulas provide the bridge between automorphism groups and the birational invariants of the curve, while the analysis of large automorphism groups leads naturally to the study of Sylow subgroups, permutation actions, and, in several instances, to results whose proofs ultimately rest on the classification of finite simple groups. The resulting picture illustrates the surprisingly rich interaction between curve theory in positive characteristic and modern finite group theory.

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Some open problems in 2D incompressible fluid dynamics

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In this talk we will discuss three major open problems concerning incompressible planar fluid flow. These are:

(1) the existence of weak solutions to the incompressible 2D Euler equations with vortex sheet initial data;
(2) the vanishing viscosity limit with no slip boundary conditions;
(3) anomalous dissipation.

We examine recent results for each of these problems and we highlight the role of a condition common to all, namely, non-concentration of vorticity.

Vorticity, the curl of velocity, is an infinitesimal measure of rotation, which in turn is an inherent feature of incompressible fluid flow.

Non-concentration of vorticity refers to excluding mass of vorticity from accumulating at points. In other words, the results we will discuss are all contingent on avoiding the spontaneous formation of point vortices.

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From Random Walks to Network Centrality: The Role of Kemeny's Constant

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Random walks on graphs and networks provide a framework across both pure and applied mathematics. Within Markov chain theory, Kemeny's constant quantifies the expected time required for a random walk to reach a target state sampled from the stationary distribution. A characteristic of this value is its independence from the starting state. In network applications, such as analyzing road systems, Kemeny's constant is used as a global measure for non-connectivity, where a larger constant indicates a poorly connected network.

In this lecture, we explore Kemeny's constant through the lens of matrix analysis, moving from its fundamental algebraic properties to recent computational and optimization results.

First, we introduce a novel edge-centrality measure based on the sensitivity of Kemeny's constant to structural perturbations. By analyzing how the constant varies upon edge removal, we demonstrate its effectiveness in identifying critical bottlenecks in road networks.

Next, we focus on the properties of Kemeny's constant within the framework of stochastic complements (Schur complements). We provide bounds and explicit expressions that allow to design a robust divide-and-conquer numerical method for its computation, suitable for large-scale graphs.

We conclude by presenting an optimization framework for minimizing Kemeny's constant in reversible Markov chains. The goal is computing the smallest modification to a given network to minimize Kemeny's constant, i.e., to improve the global communicability of the network. Numerical experiments illustrate the effectiveness of these optimization strategies in practical scenarios.

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On the existence of normalized solutions for some elliptic PDEs

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In this talk I will report on some recent contributions to the study of normalized solutions for elliptic partial differential equations in the so-called (L^2)-subcritical, (L^2)-critical, and (L^2)-supercritical regimes, with particular emphasis on Hartree-type systems. I will mainly focus on the (L^2)-supercritical case, where the analysis is generally more delicate, and present a novel approach for establishing the existence of normalized solutions. A key feature of this approach is that it follows a natural variational strategy based on minimizing the associated energy functional over the natural constraint defined by the intersection of the Pohǒzaev identity and the (L^2)-sphere. In particular, this strategy avoids any reliance on the manifold structure of this constraint, a property that, in some situations, is not known to hold. This approach applies, in particular, to scalar nonlinear Schrödinger equations, yielding alternative and simplified proofs for some results from the literature, and also leads to new existence results for Hartree-type systems.

This talk is based on a paper in collaboration with Gustavo Ramos and Eduardo Böer, both from Universidade de São Paulo.

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Curvature, Symmetry, and the Compactness of Minimal Hypersurfaces

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Take a wire loop, dip it in soap solution, and pull it out: the film that forms is a minimal surface: the shape of least possible area spanning that boundary. In higher dimensions, the same idea gives a minimal hypersurface. These objects show up throughout mathematics and physics, from soap films and architecture to the structure of 3-dimensional spaces and Einstein's theory of gravity. A natural question is whether the space of all minimal hypersurfaces is well-behaved: given a sequence of them, does some subsequence converge to another one? This is the question of compactness, and it is surprisingly delicate. I will present the classical compactness results in this area, along with examples of how compactness can fail, and then describe a new compactness theorem, obtained under a symmetry assumption.

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Positive non-radial solutions to competitive elliptic systems

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Competitive elliptic systems arise in several models, including multi-component Bose-Einstein condensates and population dynamics. While cooperative systems are relatively well understood, much less is known about the existence and structure of positive solutions in the strongly competitive regime.

In this talk I will first review some classical results on synchronized and segregated solutions and discuss the close connection between positive solutions of competitive systems and sign-changing solutions of scalar equations. I will then present a recent construction of positive non-radial solutions for a class of weakly coupled subcritical systems. The proof relies on a Lyapunov-Schmidt reduction inspired by earlier constructions for scalar equations. A key ingredient is the identification of suitable geometric configurations together with new balancing conditions governing the interaction between different components of the system.

Finally, I will discuss several open problems, including the critical and variational cases and systems with more than two components.

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The total coloring problem and its variants

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A total coloring of a graph G is an assignment of colors to the vertices and edges of G such that adjacent vertices or edges receive different colors, and each vertex has a different color from its incident edges. Determining the minimum number of colors required for a total coloring of a graph, known as the total chromatic number, occupies a pivotal position in the total coloring problem. Its central open question, known as the Total Coloring Conjecture, has remained unresolved for nearly sixty years and has motivated the development of numerous variations of the coloring problem. In this talk, open problems arising from the total coloring problem will be presented.

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