Mathematical Congress of the Americas 2013

Invited Speakers

Convention Center

August 5 - 9, 2013

5007-60-154 **M T Barlow*** (barlow@math.ubc.ca), Dept of Math, Univ. of B.C., Vancouver, B.C. V6T 1Z2, Canada, and **R Masson**. *Loop erased random walk and the uniform spanning tree.*

On a finite graph, the uniform spanning tree (UST) is just random tree chosen uniformly from the set of all spanning trees. An algorithm of Wilson gives a construction from loop erased random walks (LEW) – that is a random walk from which the loops (cycles) are erased in chronological order. The UST is an extremal member ($q = 0$) of an important class of models in statistical physics, given by the Fortuin-Kasteleyn random cluster model, where $q = 1$ is percolation and $q = 2$ relates to the Ising model. In two dimensions the LEW and UST have conformally invariant limits.

In this talk I will first survey properties of the LEW and UST, obtained by Lawler, Pemantle, Wilson, Kenyon and others. I will then describe more detailed results on the geometry of the UST in two dimensions. (Received May 03, 2013)

5007-35-262 **Nils Ackermann**, **Mónica Clapp*** (monica.clapp@im.unam.mx), **Jorge Faya** and **Angela Pistoia**. *Symmetries, Hopf fibrations and supercritical elliptic problems.*

We shall discuss the model problem

$$-\Delta v = |v|^{p-2}v \quad \text{in } D, \qquad v = 0 \quad \text{on } \partial D,$$

where D is a bounded domain in $\mathbb{R}^N$ with smooth boundary, $N \geq 3$, and $p > 2$.

The behavior of this problem depends strongly on the exponent p. Let $2^* := 2N/(N-2)$.

If $p \in (2, 2^*)$ standard variational methods yield infinitely many solutions. However, if $p \in [2^*, \infty)$, the existence of solutions becomes a delicate issue. It depends on the domain D.

Bahri and Coron established the existence of one positive solution in every domain D having nontrivial homology when $p = 2^*$. Moreover, if D is invariant under a group G of linear isometries of $\mathbb{R}^N$ and every G-orbit in D is infinite, the critical problem has infinitely many solutions.

As shown by Passaseo, these conditions are not enough to guarantee existence for $p \in (2^*, \infty)$. A fruitful approach in this case is to reduce the problem to some critical or subcritical problem in a domain of lower dimension, either by considering rotational symmetries, or by means of maps which preserve the Laplacian, or by a combination of both. I will discuss this approach and present some recent existence and nonexistence results. (Received May 10, 2013)

5007-00-465 **Fernando Coda Marques*** (coda@impa.br). *Minimal surfaces, the Willmore conjecture and the energy of links.*

In 1965, T. J. Willmore conjectured that the integral of the square of the mean curvature of any torus immersed in Euclidean three-space should be at least $2\pi^2$. In this talk I will discuss a solution to the Willmore conjecture that uses the min-max theory of minimal surfaces. This is joint work with Andre Neves. I will also describe joint work with Ian Agol and Andre Neves in which we use similar ideas to prove a conjecture of Freedman, He and Wang (1994) about the Mobius energy of links. (Received May 14, 2013)

5007-37-10 **Gonzalo Contreras*** (gonzalo@cimat.mx), CIMAT, Callejon Jalisco sn, Valenciana, 36240 Guanajuato, GTO, Mexico, **Renato Iturriaga** (renato@cimat.mx), CIMAT. Callejon Jalisco sn, Velenciana, 36240 Guanajuato, GTO, Mexico, and **Antonio Siconolfi** (siconolf@mat.uniroma1.it), Dipartamento di Matematica, Universita degli studi di Roma "La Sapienza", 00185 Roma, Italy. *Homogenization on arbitrary manifolds.*

We describe a setting for homogenization of the Hamilton-Jacobi equation on free abelian covers of compact manifolds. In this context we also provide a new simple variational proof of standard homogenization results. (Received January 30, 2013)

5007-53-76 **Octav Cornea*** (cornea@dms.umontreal.ca), Department of Mathematics and Statistics, University of Montreal, CP 6128 Succ. Centre-Ville, Montreal, Quebec H3C 3J7, Canada. *Recent advances in Lagrangian topology: cobordism and the Fukaya category.*

I will focus on a recently discovered relation between two notions that play an important role in symplectic topology and beyond. The first is cobordism: two manifolds of dimension n are cobordant if their union is the boundary of an $n+1$-dimensional manifold. The variant of this basic notion that is of interest here is Lagrangian cobordism - introduced by Arnold in 1990 - which is specific to Lagrangian sub manifolds inside an ambient symplectic manifold. The second notion is the (derived) Fukaya category that was defined by Fukaya in the early 1990's based on pioneering works of Gromov, Floer, Donaldson and Kontsevich. It was set-up in the form used here by Seidel and its construction will be sketched in the talk. The relation at the centre of the talk - to be described based on joint work of Paul Biran and the author - is of functorial nature: cobordism can be used to organize Lagrangian sub manifolds in a category and there is a meaningful functor relating this category to the derived Fukaya category. The properties of this functor reflect many remarkable phenomena specific to symplectic topology that have been discovered by various authors in the last twenty years. We intend to review a few such aspects as well as state some open problems. (Received April 23, 2013)

5007-14-316 **Alicia Dickenstein*** (alidick@dm.uba.ar), Dto. de Matematica, FCEN, Universidad de, Buenos Aires e IMAS, CONICET, Ciudad Universitaria, Pab. I, 1428EGA Buenos Aires, Argentina.

Computational algebraic geometry and biochemical reaction networks.

In recent years, techniques from computational algebraic geometry have been successfully used to address mathematical challenges in systems biology. (Bio)chemical reaction networks define systems of ordinary differential equations with (in general, unknown) parameters. Under mass-action kinetics, these equations depend polynomially on the concentrations of the chemical species. Biologically-relevant steady states correspond thus to the positive real solutions of a structured system of polynomial equations. The nonlinearities usually prevent a mathematical analysis of network behaviour, which has largely been studied by numerical simulation and lacks a more comprehensive study of the dependence on the parameters.

The algebraic theory of chemical reaction systems aims to understand their dynamic behavior by taking advantage of the inherent algebraic structure in the kinetic equations, and does not need a priori determination of the parameters, which can be practically and theoretically impossible. I will present a gentle introduction to the basic concepts and main questions, together with applications to enzymatic mechanisms. (Received May 12, 2013)

5007-06-421 **Patricio Luis Felmer*** (pfelmer@dim.uchile.cl), Avenida Blanco Encalada 2120, Santiago, Santiago, Chile. *Contributions to non-linear fractional elliptic equations.*

In this talk we review some recent results on the analysis of various problems on non-linear equations involving fractional elliptic operators. We start with the study of some limiting theorems for the heat equation with a nonlinear fractional operator, when the order of the operator approaches zero. These results are proved in the context of viscosity solutions, with an appropriate use of the comparison principle and barrier functions for bounded domains. With a related approach we then present some results for the existence of boundary blow-up solutions for these non-linear fractional elliptic equations in bounded domains, making use of the same basic approach with super and sub-solutions and barrier functions. We conclude this talk discussing another class of problems by assuming that the fractional operator has a variational formulation, providing a much richer structure to the nonlinear equations. We present applications to the non-linear Schrödinger Equation with the fractional laplacian and also some regional operators, including concentration phenomena occurring in this setting. (Received May 14, 2013)

5007-16-604 **Christof Geiss*** (christof@matem.unam.mx), Instituto de Matematicas, UNAM, Ciudad Universitaria, 04510 Mexico, D.F., Mexico. *Mutation finite cluster algebras.*

Cluster algebras were discovered arround 2002 by Fomin and Zelevinsky as an efficient combinatorial framework for problems related with dual canoical bases and total positivity. By now, there are more than 500 published papers related with cluster algebras. This is probably due to the fact that the combinatorics of cluster algebras is inhrent to many areas of mathematicsd, ranging from combinatorics of root systems over representation thory to Teichmueller theory and mathematical phyics.

In this talk we review the definitions in the context of cluster algebras coming from surfaces (Fomin, Shapiro, Thurston). Apart from this, there are only 11 more types of skew symmetric cluster algebras which are mutation finite (Felikson, Shapiro, Tumarkin).

Jacobian algebras are a fundamental tool to prove deep results about cluster algebras with representation theoretic methods. In the final part I discuss ongoing research with D. Labardini and J. Schroeer: Up to a few exceptions, the Jacobian algebras are tame if and only if they correspond to mutation finite cluster algebras. (Received May 15, 2013)

5007-68-586 **Clovis C. Gonzaga*** (ccgonzaga1@gmail.com), Florianopolis, SC , Brazil. *Complexity based methods for convex optimization.*

Computational complexity results had a great impact on continuous optimization methods in the last forty years. Upper and lower theoretical complexity bounds were developed for convex optimization, and the field of linear programming and extensions went through the interior point revolution. Recently, the great interest in very large scale problems, with millions of variables and simple constraints, motivated the evolution of complexity results for descent methods into practical algorithms which are now becoming competitive. More than a survey, this talk presents a mostly geometrical description of these techniques. (Received May 15, 2013)

5007-90-47 **Onésimo Hernández-Lerma*** (ohernand@math.cinvestav.mx), Mathematics Department, CINVESTAV-IPN, Apdo. Postal 14-740, México D.F. 07000, Mexico. *What is a* randomized strategy.

Randomized strategies—also known as mixed strategies, relaxed controls, and Young measures, among other names—can be traced back to the early 18th century in a game theoretic context. They were rediscovered by L.C. Young in a 1937 paper on the calculus of variations, and they now appear in a variety of fields, including control theory, optimization, and artificial intelligence. This talk is an introductory presentation of randomized strategies and some of their applications. One of these applications is on Young's relaxation technique to analyze some optimization problems. (Received April 05, 2013)

5007-05-570 **Yoshiharu Kohayakawa*** (yoshi@ime.usp.br), Inst. de Matemática e Estatística, USP, R. do Matão 1010, São Paulo, SP 05508-090, Brazil. *Extremal problems for random discrete structures.*

We shall discuss some extremal problems and results in the area of probabilistic combinatorics, including Turán type problems and Ramsey type problems for random graphs and problems from additive combinatorics. (Received May 15, 2013)

5007-92-365 **Mark A Lewis*** (mark.lewis@ualberta.ca), Dept Mathematical and Statistical Sciences, CAB 632, University of Alberta, Edmonton, Alberta T6G 2G1, Canada. *The mathematics behind biological invasion processes.*

Models for invasions track the front of an expanding wave of population density. They take the form of parabolic partial differential equations and related integral formulations. These models can be used to address questions ranging from the rate of spread of introduced invaders and diseases to the ability of vegetation to shift in response to climate change. In this talk I will focus on scientific questions that have led to new mathematics and on mathematics that have led to new biological insights. I will investigate the mathematical and empirical basis for multispecies invasions, for accelerating invasion waves, and for nonlinear stochastic interactions that can determine spread rates. (Received May 13, 2013)

5007-37-285 **Alejandro Maass*** (amaass@dim.uchile.cl), Blanco Encalada 2120, 7th floor, Santiago, Chile.

Cubes structures and nilsystems in topological dynamics and ergodic theory.

The connection between ergodic theory and additive combinatorics started in the 70's with Furstenberg's beautiful proof of Szemerédi's Theorem via ergodic theory. Furstenberg's proof paved the way for new combinatorial results via ergodic methods, as well as leading to numerous developments within ergodic theory. Some objects at the center of this interchange are nilsystems. They enter in ergodic theory into convergence of multiple ergodic averages, in number theory they arise in finding patterns in the primes and in combinatorics they are used to find intricate patterns in subsets of integers with positive upper density. In this talk we will discuss recent developments on the study of such fundamental factors and consequences in the complexity and recurrence theory of dynamical systems. In particular, we develop the purely algebraic concept of cube space that is behind the construction of nilfactors and give a structure theorem that characterizes nilsystems. As an application we construct the maximal nilfactors of any order in a minimal topological dynamical system and explain its role on the recurrence properties of points in a general dynamical system. (Received May 11, 2013)

5007-49-151 **Robert J McCann*** (mccann@math.toronto.edu), Department of Mathematics, University of Toronto, 40 St. George Street, Room 6290, Toronto, Ontario M5R 2Y4, Canada. *Optimal transport: old and new.*

The Monge-Kantorovich optimal transportation problem is to pair producers with consumers so as to minimize a given transportation cost. When the producers and consumers are modeled by probability densities on two given manifolds or subdomains, it is interesting to try to understand the analytical, geometric and topological features of the optimal pairing as a subset of the product manifold. This subset may or may not be the graph of a map.

This lecture describes recent developments concerning Monge's original version of this problem, and contrasts them with a capacity constrained variant in which a bound is imposed on the quantity transported between each given producer and consumer. In particular, we give a new perspective on Kantorovich's linear programming duality and expose how more subtle questions relating the structure of the solution are intimately connected to the differential topology and geometry of the chosen transportation cost. (Received May 03, 2013)

5007-22-314 **Emilio A. Lauret** and **Roberto J. Miatello*** (miatello@famaf.unc.edu.ar), FaMAF, Universidad Nacional de Córdoba, 5000 Córdoba, Argentina, and **Juan Pablo Rossetti**.

Representation equivalence & p-spectra of constant curvature space forms.

Let Γ be a discrete subgroup acting without fixed points on a simply connected constant curvature space $X = G/K$, where G is the full isometry group of X and $K = O(n)$. We will relate the eigenspaces of the Hodge-Laplace operator on p-forms on X with the irreducible constituents of the right regular representation of G on $L^2(\Gamma\backslash G)$. As a consequence, we will relate the notions of p-isospectrality with τ_p-representation equivalence, extending results of Pesce in this context. (Received May 13, 2013)

5007-11-335 **Fernando Rodriguez Villegas***, University of Texas at Austin/ ICTP. *Combinatorics and Geometry.*

We know, thanks to the work of A. Weil, that counting points of varieties over finite fields yields purely topological information about them. For example, an algebraic curve is topologically a certain number g of donuts glued together. The same quantity g, on the other hand, determines how the number of points it has over a finite field grows as the size of this field increases.

This interaction between complex geometry, the continuous, and finite field geometry, the discrete, has been a very fruitful two-way street that allows the transfer of results from one context to the other.

In this talk I will describe how we may count the number of points over finite fields of certain character varieties and discuss the geometric implications of this computation. The varieties parametrize representations of the fundamental group of a Riemann surface and are related to the moduli space of Higgs bundles on a curve.

This is joint work with T. Hausel and E. Letellier (Received May 13, 2013)

5007-37-495 **Martin Sambarino*** (samba@cmat.edu.uy), CMAT-Facultad de Ciencias, Igua 4225, 11400 Montevideo, Uruguay. *A journey on Global Dynamics.*

During the last decades there have been a lot of progress on the understanding of dynamics from a generic viewpoint. In this survey talk we will review part of this progress paying particular attention to new features and examples, the relationship between robust phenomena and dynamics of the tangent map and related results. (Received May 14, 2013)

5007-91-487 **Eva Tardos*** (eva.tardos@cornell.edu), Department of Computer Science, Ithaca, NY 14853.

Games, Auctions, Learning, and the Price of Anarchy.

Selfish behavior can often lead to suboptimal outcome for all participants, a phenomenon illustrated by many classical examples in game theory. Over the last decade, computer scientists and game theorists have developed good understanding how to quantify the impact of strategic user behavior on overall performance in environments that include selfish traffic routing, service location, and bandwidth sharing. In this talk, we will consider E-commerce applications from this perspective.

The Internet provides an environment running millions of auctions, an environment where simplicity is more important than perfect efficiency, and where the systems used do not satisfy the usual standards of mechanism design. We'll consider such auctions as games, and we discuss how to analyze such games providing robust guarantees for their performance even when players participate in multiple auctions, have valuations that are complex functions of multiple outcomes, and are using learning strategies to deal with an uncertain environment. (Received May 14, 2013)

5007-35-207 **Eduardo V Teixeira*** (teixeira@mat.ufc.br), Universidade Federal do Ceara, Av. Humberto Monte s/n, Campus do PICI - Bloco 914, Fortaleza, Ceara 60.455, Brazil. *Free boundary problems and geometric regularity theory.*

The theory of free boundary problems (FBPs) concerns the study of phenomena involving phase transitions, where governing partial differential equations must be satisfied within unknown domains. This theory is nowadays considered one of the most important directions in the mainstream of the analysis of partial differential equations. In particular, many new, deep ideas and techniques have been developed in the last two decades in order to provide an appropriate mathematical treatment to a number of FBPs. In this talk I shall discuss some recent developments in the study of a class of FBPs featuring nonlinear partial differential equations of elliptic type. I shall also discuss the impact these new ideas have in the study of regularity estimates for classical problems in elliptic PDEs. (Received May 07, 2013)

5007-35-434 **Allan Greenleaf**, **Yaroslav Kurylev**, **Matti Lassas** and **Gunther Uhlmann*** (gunther@math.washington.edu). *Cloaking: Science Meets Science Fiction.*

Can we make objects invisible? This has been a subject of human fascination for millennia in Greek mythology, movies, science fiction, etc. including the legend of Perseus versus Medusa and the more recent Star Trek and Harry Potter. In the last decade or so there have been several scientific proposals to achieve invisibility. One of the most general ways proposed to accomplish this goal has been "transformation optics" which we will describe in detail. (Received May 14, 2013)

5007-37-569 **Artur Avila**, **Sylvain Crovisier** and **Amie Wilkinson*** (wilkinso@math.uchicago.edu), Department of Mathematics, University of Chicago, 5734 S. University Avenue, Chicago, IL 60637.

The "general case".

In the early 1930s, the Ergodic theorems of von Neumann and Birkhoff put Boltzmann's Ergodic Hypothesis in mathematical terms, and the natural question was born: is ergodicity the "general case" among conservative dynamical systems? Oxtoby and Ulam tackled this question early on and showed that the answer to this question is "yes" for continuous dynamical systems. The work of Kolmogorov Arnol'd and Moser beginning in the 1950's showed that the answer to this question is "no" for C^∞ dynamical systems. I will discuss recent work with Artur Avila and Sylvain Crovisier that addresses what happens for C^1 dynamical systems. (Received May 15, 2013)