



2013-2014 ANNUAL REPORT

Mathematics  
Pan-Canadian  
Methods in Ecology, Epidemiology  
and Public Health

CRM  
CENTRE  
DE RECHERCHES  
MATHÉMATIQUES



terrestre est animé de processus  
des climats, causent des désastres  
de la vie, l'évolution des espèces  
vie. Au-delà de ces processus naturels,  
d'une grande complexité, incluant les  
des cadres de gestion des ressources, de  
des soins de santé; et des organisations  
au point où elle influence directement  
la planète de s'autosuffire et menace  
les changements climatiques, le  
des enjeux créés par l'homme, le contrôle des maladies  
des ressources et l'intégration globale sont maintenant

**HONORING 50 YEARS OF  
Models and Algorithms  
AUGUST  
AGE**

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## PRESENTATION OF THE CRM ANNUAL REPORT

It is with great pleasure that I present to you the CRM annual report for the year 2013–2014, which includes a description of the CRM activities in a new format. The year 2013–2014 was an especially brilliant one and the reach and reputation of the CRM grew even more during that time. As usual its thematic programmes were at the heart of the CRM scientific activities. One of these programmes focused on Lie theory (from January to June 2014) and was organized by Vijayanthi Chari, Erhard Neher and Alistair Savage, to whom I extend my warmest thanks. The Lie Theory Thematic Semester included two winter schools and four workshops and was very successful. The second programme in 2013–2014 was Mathematics of Planet Earth (MPE), an international programme launched by Christiane Rousseau (professor at the Université de Montréal) while she was director of the CRM (in 2008–2009). Originally conceived as a pan-canadian program, it was coopted by many institutes in several countries and enhanced the reputation of the CRM and the Québec mathematical community all over the world. I am very grateful to Christiane Rousseau, who was also vice-president of the International Mathematical Union from 2011 to 2014. The year 2013 was an intense period for the MPE programme and the CRM organized activities within three axes of MPE: (a) the international programme on celestial mechanics, (b) the pan-canadian programme on models and methods in ecology, epidemiology, and public health, and (c) the CRM thematic semester on biodiversity and evolution. Both thematic semesters (the semester on Lie Theory and the semester on Biodiversity and Evolution) featured lectures by Aisenstadt chairholders (Masaki Kashiwara, David Aldous, Simon A. Levin, and Martin Nowak). I cannot mention here all the other activities organized by the CRM and the present report does not even contain an exhaustive list of these activities. Indeed the CRM gathers all the Québec stakeholders in the mathematical sciences and the endeavours of Québec mathematicians are often related to the CRM. Nonetheless I would like to draw your attention

to the Séminaire de mathématiques supérieures or SMS (a summer school that has been held in Montréal for almost five decades), a short thematic programme, another workshop within MPE, and an industrial problem solving workshop. The topic of the SMS summer school, which was held from June 24 to July 5, 2013, was the physics and mathematics of link homology. The CRM organized a short thematic programme on rational points, rational curves, and entire curves on algebraic manifolds from June 3 to 28, 2013. In March 2014 the CRM also organized another activity within the MPE programme, namely a workshop on mathematical models and methods in laser filamentation (note that UNESCO has declared 2015 the Year of the Light). In August 2013, the Fifth Montreal Problem Solving Workshop (supported by the Mprime network) consisted of a general section including varied problems, as in the previous workshops, and a section on the physiology of connective tissue. Finally the CRM Analysis Laboratory held the first instalment of the CRM Nirenberg Lectures on geometric analysis: the 2014 lectures were given by Alessio Figalli.

In 2013–2014 the activities of our thematic programmes were attended by 951 researchers; those of the general program and the interdisciplinary and industrial program (including the activities of the CRM laboratories) were attended by 863 participants. Thus a record number of mathematicians (i.e., more than 1800) took part in our activities during that year. The reader will also find in this report information on the Grandes Conférences du CRM, on the mathematics and statistics colloquia, on the CRM laboratories, on its training activities, and on its partnerships. To conclude this presentation I wish to thank the councils and networks that allow us to fulfill our mandate through their grants: the Natural Sciences and Engineering Research Council of Canada (NSERC), the Fonds de recherche du Québec – Nature et technologies (FRQNT), the National Science Foundation of the United States and the Mprime network. Enjoy your reading!

**Luc Vinet**

Director of the CRM  
December 2014



# THEMATIC PROGRAMME

## MATHEMATICS OF PLANET EARTH 2013

### INTERNATIONAL PROGRAMME IN CELESTIAL MECHANICS (JANUARY – SEPTEMBER 2013)

THE THEMES OF THE YEAR 2013–2014 WERE MATHEMATICS OF PLANET EARTH (MPE) AND LIE THEORY. THE MPE PROGRAMME WAS CONCEIVED AS A JOINT PROGRAMME OF NORTH AMERICAN MATHEMATICAL INSTITUTES: TWELVE INSTITUTES AND THE CRM ITSELF ADOPTED MPE AND COMMITTED THEMSELVES TO ORGANIZING THEMATIC ACTIVITIES AND WORKSHOPS. IN 2010 THE MPE PROGRAMME WAS EXTENDED TO THE ENTIRE WORLD AND MORPHED INTO AN INTERNATIONAL YEAR SPONSORED BY UNESCO AND SUPPORTED BY THE INTERNATIONAL MATHEMATICAL UNION, THE INTERNATIONAL COUNCIL FOR SCIENCE, THE INTERNATIONAL COUNCIL FOR APPLIED AND INDUSTRIAL MATHEMATICS (ICIAM), AND THE INTERNATIONAL COMMISSION ON MATHEMATICAL INSTRUCTION. THE CRM BUILT THE MPE WEB SITE, DESIGNED ITS LOGO, PRODUCED THE POSTERS DISPLAYED AROUND THE WORLD, AND ORGANIZED THE VIRTUAL MODULES CONTEST OF MPE 2013. AFTER THIS INITIAL PERIOD THE ORGANIZATION OF MPE 2013 WAS DECENTRALIZED: THE MPE WEB SITE IS HOSTED BY THE AMERICAN INSTITUTE OF MATHEMATICS, THE MPE EXHIBITION IS ON THE SITE OF IMAGINARY IN OBERWOLFACH, AND OTHER RESOURCES ARE TO BE FOUND ON THE SITES OF THE PARTNERS. WITHIN THE FRAMEWORK OF MPE 2013 THE CRM ORGANIZED A THEMATIC SEMESTER, FOUR WORKSHOPS, AND ACTIVITIES GEARED TOWARDS THE GENERAL PUBLIC AND TEACHERS, INCLUDING A PANCANADIAN LECTURE SERIES (OF WHICH AT LEAST 4 TOOK PLACE IN MONTREAL OR QUÉBEC CITY), THE 57<sup>TH</sup> CONGRESS OF THE ASSOCIATION MATHÉMATIQUE DU QUÉBEC, AND TWO SPECIAL ISSUES OF THE ACCROMATH MAGAZINE. IN WHAT FOLLOWS WE DESCRIBE THE ACTIVITIES THAT TOOK PLACE AT THE CRM ITSELF.

Celestial mechanics is an important component of MPE 2013: it includes for instance the study of the influence of the Earth's motion on its climate, the monitoring of satellites, and the planning of interplanetary missions. The CRM took the lead in organizing a programme in this area, which includes workshops at the Banff International Research Station (BIRS), at the CRM, and at PIMS, as well as a summer school at the Centre International de Rencontres Mathématiques (CIRM) in Luminy (France) and the international meeting CELMEC VI. Within this programme the CRM held the workshop "Planetary Motions, Satellite Dynamics, and Spaceship Orbits," from July 22 to 26, 2013. The workshop covered a wide spectrum of topics, from the 3-body problem to the N-body problem (where N is very large if one considers the asteroid belt, planet aggregation from planetesimals, the evolution of the solar system from its beginning, or the dynamics of space debris). This workshop was organized by Alessandra Celletti (Università di Roma Tor Vergata), Walter Craig (McMaster University), Florin Diacu (University of Victoria), and Christiane Rousseau (Université de Montréal).



## PANCANADIAN PROGRAM ON MODELS AND METHODS IN ECOLOGY, EPIDEMIOLOGY, AND PUBLIC HEALTH

(JANUARY – NOVEMBER 2013)

This programme was the very first pancanadian thematic programme in the mathematical sciences. It was proposed by Christiane Rousseau, coordinated by Frithjof Lutscher (University of Ottawa), and organized by Jacques Bélair (Université de Montréal), Mark Lewis (University of Alberta), Frithjof Lutscher, James Watmough (University of New Brunswick), and Jianhong Wu (York University). This programme featured 10 workshops, of which three were organized by the CRM: “Models and Methods in Epidemiology and Ecology” (held at the CRM in February 2013), “Major and Neglected Diseases in Africa” (at the University of Ottawa in May 2013), and “Biodiversity in a Changing World” (at the CRM from July 22 to 26, 2013). The last workshop was organized by Frédéric Guichard (McGill University) and Frithjof Lutscher and benefited from the financial support of the Society for Mathematical Biology. The goal of this workshop was to gather researchers in mathematical modelling and quantitative biology in order for them to share recent experimental results, new ideas, and modelling methods for biodiversity and the impact of environmental change on biodiversity.

The lecture series by Aisenstadt Chairholder Simon A. Levin (Princeton University) was one of the highlights of the workshop on biodiversity. His first lecture was delivered on July 17, just before the workshop, and the two others on July 23 and 25, respectively. Here are the titles of these lectures: Collective phenomena, collective motion, and collective action in ecological systems; Evolutionary perspectives on discounting, public goods and collective behaviour; The Challenge of sustainability and the promise of mathematics.





## THEMATIC SEMESTER ON BIODIVERSITY AND EVOLUTION (JULY–DECEMBER 2013)

The study of biodiversity and evolution aims to understand the phenomenal variability among species, from their apparition on Earth to their extinction, by examining their intricate interactions with one another and with the physical world. Answers to the many questions arising in this field are sought through a wide range of mathematical, statistical, and computational approaches: stochastic modelling, branching processes, ancestral processes, evolutionary dynamics and games, optimization, phylogenetic inference, and maximum-likelihood methods.

The semester included five workshops. The topic of the first one was “Random Trees” (August 12–16, 2013) and it was organized by Louigi Addario-Berry (McGill University), Louis-Pierre Arguin (Université de Montréal), Rick Durrett (Duke University), and Lea Popovic (Concordia University). In this workshop mathematical methods were used to study evolutionary relations between species or between individuals within a population sample. The second workshop dealt with “Mathematics for an Evolving Biodiversity” (September 16–20, 2013) and was organized by Jonathan Davies (McGill University), Amaury Lambert (Université Paris 6 and Collège de France), and Nicolas Lartillot (Université de Montréal). The goal of this workshop was to survey theoretical and methodological developments in the modelling of the evolutionary dynamics underlying biodiversity. The topic of the third workshop was “Mathematics of Sequence Evolution: Biological Models and Applications” (September 23–27, 2013). It was organized by Mathieu Blanchette (McGill University) and Hervé Philippe (Université de Montréal) and dealt with the most recent (mathematical or algorithmic) approaches for developing evolutionary models of sequences or genomes.

The fourth workshop, entitled “Coalescent Theory: New Developments and Applications” (October 7–11, 2013) was organized by Philip Awadalla (Université de Montréal), Robert C. Griffiths (University of Oxford), Fabrice Larribe (UQAM), and Sabin Lessard (Université de Montréal). Its topic was the “backward perspective” on evolution in large finite populations, which provides a link between evolutionary models and empirical data. The fifth and last workshop (“Biodiversity and Environment: Viability and Dynamic Games Perspectives”) took place from November 4 to 8, 2013, and was organized by Hassan Benčekroun (McGill University), Michèle Breton (HEC Montréal), Sabin Lessard (Université de Montréal), Patrick Saint-Pierre (Université Paris Dauphine), and Georges Zaccour (HEC Montréal). The themes of this workshop were the mathematical modelling of complex systems under uncertainty, the evolution of cooperation through individual or species interactions in common goods games, and the design of mechanisms for adaptation and survival. To conclude let us mention that the Thematic Semester on Biodiversity and Evolution also included lecture series given by two Aisenstadt Chairholders, David Aldous (Berkeley) and Martin Nowak (Harvard), and by the Clay Senior Scholar for the Semester, Robert C. Griffiths (Oxford).



## LIE THEORY

The second theme of the year 2013-2014 was Lie Theory. The Thematic Semester on "New Directions in Lie Theory" took place from January to June 2014 and was organized by Vyjayanthi Chari (UC Riverside) and Erhard Neher and Alistair Savage (both from the University of Ottawa). Here is their report on the thematic semester.

Lie theory is a fundamental area of modern mathematics, with applications to many different disciplines. It has a long and successful tradition in Canada, as do combinatorics and the representation theory of associative algebras. The focus of the thematic semester reflected the new connections between these subjects. It highlighted current research in Lie theory and its applications to other fields, while fostering interaction between Canadian and foreign researchers and providing a forum for young mathematicians to learn about the current trends in the subject and interact with the leading experts in this exciting field.

The program began with a winter school that took place on January 6-17 and featured two courses aimed at graduate students and postdoctoral fellows. The course "Introduction to categorification" by Alistair Savage introduced students to the new and exciting field of categorification and helped prepare them for the workshop on Geometric representation theory and categorification. The second course of the winter school, Introduction to Kac-Moody and related Lie algebras by Erhard Neher, complemented typical first courses on Lie algebras offered at many universities and served as preparation for the course Representation theory of semisimple and affine Kac-Moody algebras (offered in the second winter school). The first winter school was very successful, with 34 participants, many of them actively participating in the problem sessions of the two courses.

The second winter school of the semester took place on February 24 – March 7. The course Representation theory of semisimple and affine Kac-Moody algebras by Vyjayanthi Chari focused in the first week on the category  $\mathcal{O}$  for finite-dimensional simple Lie algebras and in the second week on the representation theory of affine Lie algebras. The second course of the winter school, Vertex algebras for mathematicians by Michael Lau (Laval), introduced students to vertex algebras and operator product expansion from first principles, with applications to Lie algebras, representation theory, and modular forms. The second winter school was also a huge success, with 24 active participants.

The winter schools were followed by four week-long workshops. The first of these, Combinatorial representation theory (April 21-15), featured 18 talks by both junior and senior mathematicians and was attended by 75 participants. It also coincided with the visit of Aisenstadt Chair Masaki Kashiwara (Kyoto University). Professor Kashiwara delivered two research talks in addition to a general audience lecture. The second workshop, Hall and cluster algebras (May 8-12), included talks by 19 researchers and was attended by 58 mathematicians. The third workshop, Lie theory and mathematical physics (May 19-23), was attended by 60 participants and included 18 research talks. The semester concluded with the workshop Categorification and geometric representation theory, in which 82 participants enjoyed talks by 20 mathematicians. The participants of the workshops consisted of a broad cross-section of mathematicians from all over the world, both junior and senior. Many of the junior participants (graduate students and postdoctoral fellows) received financial support from the CRM, the NSF, or the Fields Institute.

Throughout the semester the CRM was home to a total of 27 long-term visitors, both junior and senior, many of whom participated in the workshops and several of which were postdoctoral researchers. Also two resident postdoctoral fellows, Daniele Rosso and Rajendran Venkatesh, were affiliated with the semester. In addition to the winter schools and workshops, the semester saw activity in the form of seminars. In particular, a special learning seminar on Kac-Moody algebras was led by Erhard Neher and provided an opportunity for graduate students and postdoctoral fellows to work through fundamental material in the field and present exercises to each other. During the months of March through May, the semester also featured a visitor seminar where talks were given by mathematicians visiting the CRM as a part of the thematic program. Overall the semester achieved its goals in a brilliant manner. Its activities have spurred research in Lie theory and related fields, built connections between junior and senior researchers, and helped to underline the strength of Canadian mathematics in this fascinating field.





## PAST THEMATIC PROGRAMS

The Centre de recherches mathématiques has organized thematic activities every year since 1993. From 1987 to 1992 the CRM organized various types of activities, including special semesters, concentration periods, and thematic activities. Here is a list of the main activities organized by the CRM since 1987.

**2013** Mathematics of Planet Earth 2013 – PanCanadian Program on models and methods in ecology, epidemiology, and public health

**2012–2013** Moduli Spaces, Extremality and Global Invariants

**January–June 2012** Geometric Analysis and Spectral Theory

**June–December 2011** Quantum Information

**January–June 2011** Statistics

**July–December 2010** Geometric, Combinatorial and Computational Group Theory

**January–April 2010** Number Theory as Experimental and Applied Science

**August–December 2009** Mathematical Problems in Imaging Science

**2008–2009** Joint CRM–PIMS Program: Challenges and Perspectives in Probability

**2008–2009** Probabilistic Methods in Mathematical Physics

**January–June 2008** Dynamical Systems and Evolution Equations

**June–December 2007** Applied Dynamical Systems

**January–June 2007** Recent Advances in Combinatorics

**June–December 2006** Combinatorial Optimization

**2005–2006** Analysis in Number Theory

**2004–2005** The Mathematics of Stochastic and Multiscale Modelling

**2003–2004** Geometric and Spectral Analysis

**2002–2003** Mathematics in Computer Science

**2001–2002** Groups and Geometry

**2000–2001** Mathematical Methods in Biology and Medicine

**1999–2000** Mathematical Physics

**1998–1999** Number Theory and Arithmetic Geometry

**1997–1998** Statistics

**1996–1997** Combinatorics and Group Theory

**1995–1996** Applied and Numerical Analysis

**1994–1995** Geometry and Topology

**1993–1994** Dynamical Systems and Applications

**1992** Probability and Stochastic Control (special semester)

**1991–1992** Automorphic Forms in Number Theory

**1991** Operator Algebras (special semester)

**1990** Nonlinear PDEs and Applications (concentration period)

**1988** Shimura Varieties (special semester)

**1987** Quantum Field Theory (special semester)

**1987–1988** Fractals: Theory and Application

**1987** Structural Rigidity (special semester)

## THE AISENSTADT CHAIR

The Aisenstadt Chair was endowed by Montréal philanthropist Dr. André Aisenstadt. Each year one or more distinguished mathematicians are invited to spend at least one week (ideally one or two months) at the CRM. During their stay these mathematicians deliver a series of lectures on a specialized topic. They are also invited to prepare a monograph. At the request of Dr. Aisenstadt, the first lecture given by an Aisenstadt Chairholder should be accessible to a wide audience. Generally speaking the research fields of the Chairholders are closely related to the CRM thematic programs for the current year.

## THE 2013–2014 AISENSTADT CHAIRHOLDERS

**SIMON A. LEVIN** is the George M. Moffett Professor of Biology at Princeton University in the Department of Ecology and Evolutionary Biology. He is one of the foremost world experts in mathematical models in biology. He has received numerous prizes and distinctions, including the A.H. Heineken Prize for Environmental Sciences, the Kyoto Prize in Basic Sciences, and the Ramon Margalef Prize in Ecology and Environmental Sciences. Professor Levin's research interests are the complexity of ecological, behavioural, and evolutionary mechanisms in organisms and their influence on macroscopic patterns and processes. In recent years Professor Levin has turned his attention to the parallels between ecological systems and financial and economic systems. During his stay at the CRM he delivered the three lectures mentioned above.

**DAVID ALDOUS** is an expert in probability theory and its applications, in particular exchangeability, weak convergence, Markov chain mixing times, continuous random trees, and stochastic coalescence. He received his doctorate from the University of Cambridge and has been a professor at the University of California at Berkeley since 1979. Professor Aldous has been awarded the Rollo Davidson Prize in 1980 and the Loève Prize in 1993. He was elected a Fellow of the Royal Society in 1994, of the American Academy of Arts and Sciences in 2004, and of the American Mathematical Society in 2012. Here are the titles of the three lectures that David Aldous delivered as Aisenstadt Chairholder at the CRM: "What Does Mathematical Probability Tell us about the Real World?" (August 12, 2013); "Interactive Particle Systems as Stochastic Social Dynamics" (August 14, 2013); and "The Compulsive Gambler and the Metric Coalescent" (August 16, 2013).





**MARTIN NOWAK** obtained his doctorate from the University of Vienna in 1989. After spending a few years at the University of Oxford, he established the first program in theoretical biology at the Institute for Advanced Study (Princeton). He has been a professor of mathematics and biology at Harvard University since 2003. Professor Nowak has been invited to deliver prestigious lectures (in particular the Radon Lecture at the Austrian Academy of Sciences and the Coxeter Lectures at the Fields Institute) and has been awarded many prizes, among which the Akira Okubo Prize and the Henry Dale Prize (by the Royal Institution in London). Professor Nowak is the director of the Program for Evolutionary Dynamics at Harvard University and makes use of mathematical models in order to describe evolutionary processes, including the evolution of cooperation and human language and the dynamics of cancer and viral infections. Here are the titles of the three lectures that Martin Nowak gave as Aisenstadt Chairholder at the CRM (respectively on November 4, 6, and 7, 2013): “Evolution of Eusociality;” “The Evolution of Cooperation: Why We Need Each Other to Succeed;” and “Evolutionary Dynamics.” His second lecture was also a Grande Conférence du CRM.

**MASAKI KASHIWARA** is a professor at the University of Kyoto and was Aisenstadt Chairholder for the thematic semester on Lie Theory. He has made fundamental contributions to algebraic analysis, microlocal analysis, the theory of D-modules, Hodge Theory, the theory of sheaves, and representation theory. In collaboration with Sato he laid down the foundations of the study of linear partial differential equations with analytic coefficients and introduced a cohomological approach inspired by Grothendieck’s theory of schemes. In his master’s thesis Kashiwara gave the foundations of the theory of D-modules; his doctoral thesis includes a proof that the roots of b-functions are rational. Professor Kashiwara is a member of the French Academy of Sciences and the Japan Academy. The Aisenstadt Chair Lectures given by Professor Kashiwara took place on April 21, 22, and 24, 2014 (respectively). They were entitled: “Symmetric Quiver Hecke Algebras and R-matrix;” “Parameters of Quiver Hecke Algebras;” and “Riemann–Hilbert Correspondence for Irregular Holonomic D-modules.” The third of these lectures was geared towards a wide audience.



## PREVIOUS AISENSTADT CHAIRHOLDERS

Marc Kac, Eduardo Zaranonello, Robert Hermann, Marcos Moshinsky, Sybren de Groot, Donald Knuth, Jacques-Louis Lions, R. Tyrrell Rockafellar, Yuval Ne’eman, Gian-Carlo Rota, Laurent Schwartz, Gérard Debreu, Philip Holmes, Ronald Graham, Robert Langlands, Yuri Manin, Jerrold Marsden, Dan Voiculescu, James Arthur, Eugene B. Dynkin, David P. Ruelle, Robert Bryant, Blaine Lawson, Yves Meyer, Ioannis Karatzas, László Babai, Efim I. Zelmanov, Peter Hall, David Cox, Frans Oort, Joel S. Feldman, Roman Jackiw, Duong H. Phong, Michael S. Waterman, Arthur T. Winfree, Edward Frenkel, Laurent Lafforgue, George Lusztig, László Lovász, Endre Szemerédi, Peter Sarnak, Shing-Tung Yau, Thomas Yizhao Hou, Andrew J. Majda, Manjul Bhargava, K. Soundararajan, Terence Tao, Noga Alon, Paul Seymour, Richard Stanley, John J. Tyson, John Rinzel, Gerhard Huisken, Jean-Christophe Yoccoz, Wendelin Werner, Andrei Okounkov, Svante Janson, Craig Tracy, Stéphane Mallat, Claude Le Bris, Akshay Venkatesh, Alexander Razborov, Angus MacIntyre, Yuri Gurevich, Jamie Robins, Renato Renner, John Preskill, Richard M. Schoen, László Erdős, Elon Lindenstrauss, Fedor Bogomolov, Helmut Hofer, David Gabai, Gang Tian

# OTHER ACTIVITIES

THE CRM ORGANIZES MANY ACTIVITIES APART FROM ITS THEMATIC PROGRAMMES: THE SÉMINAIRE DE MATHÉMATIQUES SUPÉRIEURES OR SMS (A SUMMER SCHOOL HELD IN MONTRÉAL ALMOST EVERY YEAR SINCE ITS BEGINNINGS IN THE 1960S); SHORT THEMATIC PROGRAMMES; ACTIVITIES IN VARIOUS FIELDS OF THE MATHEMATICAL SCIENCES (THE CRM GENERAL PROGRAMME); INTERDISCIPLINARY AND INDUSTRIAL ACTIVITIES; AND ACTIVITIES ORGANIZED BY THE CRM LABORATORIES. THE CRM ALSO SPONSORS ACTIVITIES THAT DO NOT TAKE PLACE ON ITS PREMISES AND ACTIVITIES ORGANIZED BY OTHER INSTITUTIONS. THE READER WILL FIND BELOW THE MAIN ACTIVITIES ORGANIZED OR SPONSORED BY THE CRM IN 2013–2014.

## SUMMER SCHOOL

### Séminaire de mathématiques supérieures – SMS 2013 Physics and Mathematics of Link Homology June 24 – July 5, 2013, at the CRM

*Sponsored by the CRM, the Fields Institute, PIMS, MSRI, and the Simons Foundation*

**Organizers:** Sergei Gukov (Caltech), Mikhail Khovanov (Columbia), and Johannes Walcher (McGill)

At the beginning of the SMS, more than 50 years ago, the summer school was sponsored by NATO and organized by the Department of mathematics and statistics of the Université de Montréal. As time went by, the association between the CRM and the SMS became stronger and stronger. The SMS is not sponsored by NATO any more: its support comes from the CRM, the Fields Institute, PIMS, and the Mathematical Sciences Research Institute (MSRI) at Berkeley. In 2013 the theme of the SMS was the physics and mathematics of link homology, a deep and exciting theme at the frontier of topology and mathematical physics. More than 90 students and postdoctoral fellows took part in this summer school. For the first time all courses delivered during the school were recorded on video. Here are the names and affiliations of the instructors and the course titles.

**MINA AGANAGIC** (Berkeley)  
Knots and string dualities

**DROR BAR-NATAN** (Toronto)  
A quick introduction to Khovanov homology (I, II, III)

**SERGEI GUKOV** (Caltech)  
Overview of physics of knot homologies

**HIROKI FUJI** (Tokyo)  
The volume conjecture and super-A-polynomial

**JOEL KAMNITZER** (Toronto)  
Knot homology via the affine Grassmannian

**ANTON KAPUSTIN** (Caltech)  
Abelian Chern-Simons theory as an extended topological field theory

**MIKHAIL KHOVANOV** (Columbia)  
Categorification of the HOMFLYPT polynomial and its specializations

**AARON LAUDA** (Southern California)  
Knot invariants and their categorifications via Howe duality

**CIPRIAN MANOLESCU** (UCLA)  
An introduction to knot Floer homology (first course)  
From knot Floer homology to invariants of 3- and 4-manifolds (second course)

**MARCOS MARIÑO** (Genève)  
Integrality properties of link invariants from topological strings

**ALEXEI OBLONKOV** (Amherst)  
Topology of planar curves, knot homology and representation theory of Cherednik algebras

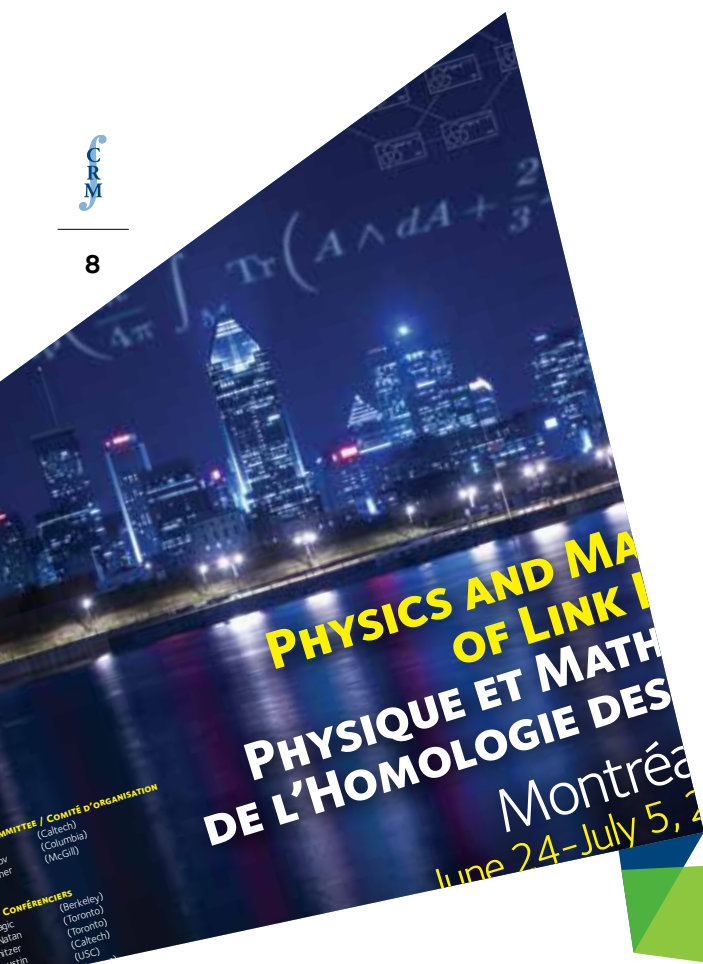
**RAMADEVI PICHAI** (Bombay)  
Chern-Simons theory and knot invariants

**JAKE RASMUSSEN** (Cambridge)  
Differentials on knot homologies

**MARKO STOSIC** (Lisbonne)  
Colored HOMFLY homology of knots and links

**JOHANNES WALCHER** (McGill)  
Matrix factorizations and topological strings for knots

**BEN WEBSTER** (Northeastern)  
Knot homology, KLR algebras and quiver varieties





## SHORT THEMATIC PROGRAM

### Rational Points, Rational Curves and Entire Holomorphic Curves on Projective Varieties

June 3–28, 2013, at the CRM

*Sponsored by CIRGET (a CRM laboratory), the Agence nationale de la recherche (France), and the National Science Foundation*

**Organizers:** Carlo Gasbarri (Strasbourg), Steven Lu (UQAM), Erwan Rousseau (Université de Provence), Jason Starr (Stony Brook), and Yuri Tschinkel (Courant Institute, NYU)

The last years have seen major advances in the geometry of algebraic varieties, especially in its analytical, arithmetic, and algebraic aspects. Fundamental conjectures (due to Green–Griffiths, Lang, Mazur, Vojta, and recently Campana) have served as guidelines for research works that were independent but parallel, within each of the aspects mentioned. The explosion in breakthroughs (including new results and new techniques) required the fostering of exchanges between these disparate communities. The goal of this short programme was to foster such exchanges and it was very successful, as the publication of its proceedings by the CRM demonstrates. One of the most important themes of the programme was the recent progress in the classification of algebraic varieties in birational geometry, especially in our knowledge of the role played by rational curves in the study of the arithmetic and holomorphic properties of an algebraic variety and in our understanding of the key role of the canonical bundle and related tensorial bundles in the study of algebraic and holomorphic curves.

The short programme on rational points, rational curves, and entire curves lasted for one month and was at the same time a summer school (introducing the participants to advanced topics) and a gathering of experts for cross-pollination. The first three weeks served as a summer school, whose courses were interspersed with advanced talks. This summer school featured eight mini-courses (each consisting of four lectures), given respectively by Claire Voisin (École Polytechnique), Jorge Vitorio Pereira (IMPA Estrada Dona Castorina),

Jason Starr (Stony Brook), Carlo Gasbarri, Michael Nakamaye (New Mexico), Henri Gillet (Illinois at Chicago), Paul Vojta (Berkeley), and Yuri Tschinkel. The summer school also featured regular problem sessions ran by Jason Starr and a public lecture by Antoine Chambert–Loir. The final week of the programme featured a fast-paced workshop, with speakers documenting many of the recent advances in their subjects. The conference was well attended and its participants came from all corners of the world.

## MATHEMATICS OF PLANET EARTH

In March 2014 the CRM organized a workshop under the umbrella of the MPE program (not part of the thematic activities mentioned above). This workshop was supported by an international network of institutes as well as UNESCO, which launched the International Year of Light and Light-Based Technologies (IYL 2015).

### Mathematical Methods and Models in Laser Filamentation

March 10–14, 2014, at the CRM

*Sponsored by the National Science Foundation*

**Organizers:** André Bandrauk (Sherbrooke), Emmanuel Lorin de la Grandmaison (Carleton), and Jerome V. Moloney (Arizona)

This workshop gathered mathematicians and physicists who are experts in nonlinear optics and filamentation. The goal of the workshop was to derive and analyze nonperturbative models in order to understand the physics of filamentation. These models (and the associated numerical methods) are based on the equations of Schrödinger, Dirac, and Maxwell, which allow us to model the nonlinear nonperturbative regime of the interactions between lasers (one one hand) and gas and solids (on the other). Those models have applications in communications, surgery, and atmospheric sciences. In particular the interaction between intense laser pulses and the atmosphere is a very important research area within this international programme and the CRM workshop was the first activity held in Canada on this topic. The workshop proceedings, based on the presentations of invited lecturers, will be published by the CRM and Springer. Finally, because of the success of this workshop, Professor Bandrauk and his colleagues were invited to co-organize COFIL 2016 (International Symposium on Filamentation) by the COFIL 2016 International Committee.



## THE CRM GENERAL PROGRAMME

The general programme of the CRM funds a wide variety of scientific events, both on the premises of the CRM and elsewhere in Canada. Whether it be for specialized workshops attended by a small number of researchers or large meetings attended by hundreds of participants, the general program promotes research in the mathematical sciences at all levels. The program is quite flexible, allowing projects to be considered as they arise.

## GENERAL PROGRAMME: ACTIVITIES HELD AT THE CRM

### 15th IMS New Researchers Conference in Statistics and Probability August 1-3, 2013, at the CRM

*Sponsored by the IMS (Institute of Mathematical Statistics), the Statistical Society of Canada, the National Science Foundation, the National Institutes of Health, the CRM, and the Institut des sciences mathématiques (ISM)*

**Organizers:** Aarti Singh (CMU, Organizing Committee Chairman), Edoardo Airoldi (Harvard), David Anderson (Wisconsin), Ery Arias-Castro (UC San Diego), Cecilia Cotton (Waterloo), Johanna Nešlehová (McGill, Local Organizer), Davy Paindaveine (Bruxelles), Soumik Pal (Washington), Debashis Paul (UC Davis), Amandine Veber (École Polytechnique), and Shuang Wu (Rochester)

### Workshop Invariant Subspaces of the Shift Operator August 26-30, 2013, at the CRM

*Sponsored by the CRM Analysis Laboratory*

**Organizers:** Emmanuel Fricain (Lille 1), Javad Mashreghi (Laval), and William Ross (Richmond)

### Workshop From Categories to Logic, Linguistics and Physics: A Tribute for the 90th Birthday of Joachim Lambek September 21, 2013, at the CRM

### Workshop SCHOLAR – A Scientific Celebration Highlighting Open Lines of Arithmetic Research in Honour of Professor M. Ram Murty's Mathematical Legacy on his 60th Birthday October 15-17, 2013, at the CRM

*Sponsored by the CRM, the Fields Institute, and the Number Theory Foundation*

### Directors' Symposium le 8 novembre 2013, au CRM

*Sponsored by the CRM, the Fields Institute, and PIMS*

## GENERAL PROGRAMME: ACTIVITIES SUPPORTED BY THE CRM

### Conference CanadAM 2013 June 10-13, 2013, at Memorial University (Newfoundland)

*Sponsored by AARMS, the CRM, the Fields Institute, PIMS, and Memorial University*

**Program Committee:** Daniel Panario (Carleton, Chair), Brett Stevens (Carleton), Cédric Chauve (Simon Fraser), Sylvie Corteel (Université Paris-Diderot, France), Antoine Deza (McMaster), Penny Haxell (Waterloo), Christophe Hohlweg (UQAM), Jeannette Janssen (Dalhousie), Jennifer Key (Clemson, South Carolina), Brendan McKay (Australian National University), Ian Munro (Waterloo), Wendy Myrvold (Victoria), Ortrud Oellermann (Winnipeg), and Dana Randall (Georgia Institute of Technology)

**Executive Committee:** Frank Ruskey (Victoria, Chair), Gary MacGillivray (Victoria), Odile Marcotte (UQAM and CRM), David Pike (Memorial), Brett Stevens (Carleton), and Lorna Stewart (Alberta)

**Local Arrangements Committee:** David Pike (Memorial, Chair), Danny Dyer (Memorial), Nabil Shalaby (Memorial), and Ryan Tifenbach (Memorial)

This conference, whose first instalment took place in 2007, was immediately recognized as the most important Canadian forum in discrete and algorithmic mathematics. It is now also a world-class conference in this field of the mathematical sciences.

### Analysis and Partial Differential Equations: A Conference in Honour of the 60th Birthday of Nassif Ghoussoub July 7-12, 2013, at the University of British Columbia

*Sponsored by the CRM, the Fields Institute, PIMS, Mitacs, and the National Science Foundation*

**Scientific Committee:** K.C. Chang (Beijing), Ivar Ekeland (Paris), Joel Feldman (UBC), Changfeng Gui (Connecticut), Bill Johnson (Texas), Louis Nirenberg (NYU), Gabriella Tarantello (Rome), and Nicole Tomczak-Yaegermann (Alberta)

**Local Committee:** Stephen Gustafson (UBC), Young-Heon Kim (UBC), Dong Li (UBC), Abbas Moameni (Lethbridge), Tai-Peng Tsai (UBC), Juncheng Wei (UBC), and Meijun Zhu (Oklahoma)



## Canadian Undergraduate Mathematics Conference 2013

**July 10-14, 2013,  
at the Université de Montréal**

*Sponsored by the Institut des sciences mathématiques (ISM), the FAÉCUM, the Canadian Mathematical Society (CMS), the CRM, AARMS, the Fields Institute, the Communications Security Establishment (Canada), the Department of mathematics and statistics of the Université de Montréal, CICMA, the Association des statisticiennes et statisticiens du Québec, the Statistical Society of Canada (SSC), and IMETRIK*

**Organizers:** Jean Lagacé (Chair of the Organizing Committee), Nicolas Bouchard, Kevin Gervais, Andréanne Lapointe, Vincent Létourneau, Joanie Martineau, Audrey Morin, and Nicolas Simard, all students at the Université de Montréal

## Mathematical Congress of the Americas 2013

**August 5-9, 2013,  
in Guajajuato (Mexico)**

*Sponsored by the American Mathematical Society, the Brazilian Mathematical Society, the Canadian Mathematical Society, the Mathematical Union of Latin America and the Caribbean, the Mexican Mathematical Society, the Society for Industrial and Applied Mathematics (SIAM), and CONACYT (Consejo Nacional de Ciencia y Tecnología)*

**Steering Committee:** Alejandro Ádem (Canada), Uri Ascher (Canada), Susan Friedlander (États-Unis), Servet Martínez (Chili), José Antonio de la Pena (Mexico), and Marcelo Viana (Brésil)

This congress is the equivalent, for the Americas, of the prestigious International Congress of Mathematicians. The congress that took place in Mexico was the first instalment of the Mathematical Congress of the Americas. The second instalment will take place in Montréal.

## 57th Congress of the Association mathématique du Québec ("Mathématiques québécoises de la planète Terre")

**October 11-12, 2013,  
at the Royal Military College Saint-Jean**

## Colloquium (Entretiens Jacques-Cartier 2013)

**Mathematics and Climate Change  
November 27-28, 2013,  
at the CNRS Rhône Auvergne**

*Sponsored by the Centre Jacques-Cartier and the CNRS*

### Scientific Organizers for France:

Éric Blayo (Grenoble), Didier Bresch (Chambéry), and Daniel Le Roux (Lyon 1)

### Scientific Organizers for Québec:

Peter Bartello (McGill), Laurent Habsieger (CNRS UMI 3457, Montréal), and René Laprise (UQAM)

## Seminars in Undergraduate Mathematics in Montréal - SUMM 2014

**January 10-12, 2014,  
at Concordia University**

*Sponsored by Concordia University, McGill University, the Université de Montréal, UQAM, the Canadian Mathematical Society, the CRM, the ISM, and Maplesoft*

**Organizers:** Joey Litalien, Renaud Raquépas, Erick Schulz, and David Kleiman

## Canadian Mathematics Education Forum

**May 1-4, 2014,  
at the University of Ottawa**

*Sponsored by the University of Ottawa, the CRM, AARMS, the Fields Institute, PIMS, Pearson ERPI, the Statistical Society of Canada, and Crowdmark*

**Organizers:** Ann Arden (Osgoode Township District High School and University of Ottawa), Richard Hoshino (Quest University Canada), Kathleen Pineau (École de technologie supérieure), Peter Taylor (Queen's University), and Sarah Watson (Canadian Mathematical Society)

## Colloque panquébécois des étudiants de l'Institut des sciences mathématiques XVIIth edition

**May 16-18, 2014, at Université Laval**

*Sponsored by the Institut des sciences mathématiques (ISM), the FRQNT, the CRM, the Association des étudiants gradués en science et génie, Université Laval, the Fields Institute, the Association des Étudiant(e)s en Statistique et Mathématiques (Université Laval), the Canadian Mathematical Society, and the Association des étudiantes et étudiants de Laval inscrits aux études supérieures*



## PROBLEM SOLVING WORKSHOPS

The CRM has been organizing problem solving workshops since 2007. These workshops gather industry representatives, university researchers, postdoctoral fellows, and graduate students. The participants work in teams, each of which studies a problem supplied by a company or a public or quasi-public institution. The main workshop goals are to give companies or institutions mathematical tools for solving their problems and to allow mathematicians working in an academic environment to analyze and solve real-world problems. The workshops organized by the CRM are part of a Canadian tradition since PIMS and the Fields Institute also organize problem solving workshops.

In August 2013 the CRM organized the Fifth Montreal Problem Solving Workshop. For the first time at the CRM this workshop consisted of two sections: a section devoted to mathematical problems arising in connective tissue physiology (organized by Svetlana Komarova from McGill and Nilima Nigam from Simon Fraser University) and a general section including diverse problems. The CRM is very grateful to the following companies and institutions, which supplied the problems studied during the workshop: Western University (London, Ontario), Matrix Dynamics, the University of Toronto Faculty of Dentistry, the McGill University Faculty of Dentistry, the Shriners Hospitals for Children (Montréal), IREQ, GIRO, and RedPrairie-JDA.

### **Fifth Montreal Problem Solving Workshop - A CRM-Mprime Event August 19-23, 2013, at the CRM**

*Sponsored by the Mprime network, the Matrix Dynamics Group at the University of Toronto, GERAD, and the Network for Oral and Bone Health Research (RSBO)*

**Organizers:** Fabian Bastin (Université de Montréal), Gilles Caporossi (HEC Montréal), Michel Gendreau (École Polytechnique de Montréal), Bernard Gendron (Université de Montréal), Huaxiong Huang (York University), Svetlana Komarova (McGill), Odile Marcotte (CRM and UQAM), Nilima Nigam (Simon Fraser University), Dominique Orban (École Polytechnique de Montréal), Sylvain Perron (HEC Montréal), Christiane Rousseau (Université de Montréal), Jean-Marc Rousseau (CIRANO and ncm<sub>2</sub>), Chair, and Louis-Martin Rousseau (École Polytechnique de Montréal)

## INTERDISCIPLINARY AND INDUSTRIAL PROGRAMME

The CRM organizes and supports several activities of an “interdisciplinary or industrial” nature, apart from the problem solving workshops. Here is a list of those activities that took place in 2013-2014. Note that Professor David Sankoff, a pioneer in the field of evolutionary genomics, has been a member of the CRM since its founding and conducted the major part of his research at the centre.

### **MAGE Models and Algorithms for Genome Evolution A Conference Honouring David Sankoff's 50th Anniversary of Research Contribution August 23-26, 2013, at the Château-Bromont Hotel**

*Sponsored by the CRM, the Université de Montréal, the Fields Institute, the National Science Foundation, IBM Research, CIFAR, PIMS, and the University of Ottawa*

**Organizers:** Cédric Chauve (Simon Fraser University), Dannie Durand (Carnegie Mellon), Nadia El-Mabrouk (Montréal), Laxmi Parida (IBM Research), and Éric Tannier (INRIA and Université de Lyon)

### **Workshop Scale-Free Dynamics and Networks in Neurosciences October 21-24, 2013, at the CRM**

*Sponsored by the Québec Bio-imaging Network (QBIN)*

**Organizers:** Philippe Ciuciu (CEA/Neurospin and INRIA) and Jean-Marc Lina (École de technologie supérieure)

### **5th workshop on Game Theory in Energy, Resources and Environment May 26-27, 2014, at HEC Montréal**

*Sponsored by HEC Montréal, GERAD, the CRM, the International Society on Dynamic Games (ISDG), and the FRQNT*

**Organizer:** Georges Zaccour (HEC Montréal)







Algorithms for Genome Evolution  
AUGUST 23-26, 2013 BY DAVID SAN  
Bromont, Québec

A volume of the Computational Biology series of Springer entitled "Models and Algorithms for Genome Evolution", gathering contributions from MAGE participants, will be published following the conference (editors: Cédric Chauve, Nadia El-Mabrouk and Éric Tannier).

## ACTIVITIES ORGANIZED BY THE CRM LABORATORIES

The CRM activities described so far are organized to a large extent by mathematicians who belong to at least one laboratory of the CRM. The CRM members, however, also organize activities that are proposed and supported by the laboratories themselves. In particular, in 2014, the Analysis Laboratory created the Nirenberg lectures in honour of the famous mathematician Louis Nirenberg, who spent part of his life in Montréal. Here is a list of the activities that were organized by the laboratories in 2013-2014.

### Words, Codes and Algebraic Combinatorics A conference in honour of Christophe Reutenauer's 60<sup>th</sup> birthday July 1-5, 2013, in Cetraro (Italy)

*Sponsored by the CNRS, LaCIM, UQAM, La Sapienza (Università di Roma), the CRM, the Università Degli Studi di Salerno, and the GNSAGA*

**Organizers:** Clelia de Felice (Salerno), Christophe Hohlweg (UQAM), Claudia Malvenuto (Sapienza), and Guy Melançon (Bordeaux I)

### Montreal-Toronto Workshop in Number Theory Progress and Prospects in Number Theory November 23-24, 2013, at the Fields Institute

*Sponsored by the CRM, CICMA, and the Fields Institute*

**Organizers:** Eyal Goren (McGill) and Stephen Kudla (Toronto)

### 4th Graduate Students Workshop on Actuarial and Financial Mathematics December 6, 2013, at the CRM

*Sponsored by the Statistics Laboratory*

**Organizers:** Mathieu Boudreault (UQAM), José Garrido (Concordia), Ghislain Léveillé (Laval), and Manuel Morales (Montréal)

### Workshop on Nonparametric Curve Smoothing December 16-17, 2013, at Concordia University

*Sponsored by the Statistics Laboratory*

**Organizers:** Yogendra P. Chaubey (Concordia), Nikolay Gospodin (Concordia), Adam Krzyzak (Concordia), Arusharka Sen (Concordia), and Taoufik Bouezmarni (Sherbrooke)

### 3rd Workshop on Insurance Mathematics January 31, 2014, at Université Laval

*Sponsored by Université Laval, the CRM, the Statistics Laboratory, Co-operators, and the Canada Research Chairs*

**Organizers:** Manuel Morales (Montréal), Jean-François Renaud (UQAM), Étienne Marceau (Laval), David Landriault (Waterloo), Andrei L. Badescu (Toronto), Hélène Cossette (Laval), and Ghislain Léveillé (Laval)

### Nirenberg Lectures in Geometric Analysis at the CRM Stability results for geometric and functional inequalities

by Alessio Figalli (University of Texas at Austin)

**May 13-16, 2014, at the CRM**

*Sponsored by the Analysis Laboratory*

# "GRANDES CONFÉRENCES DU CRM" AND COLLOQUIA

## THE MATHEMATICS OF EVOLUTION

**Robert Griffiths**  
(University of Oxford)

Robert Griffiths visited the CRM in 2013 as Clay Senior Scholar for the Thematic Semester on Biodiversity and Evolution. He obtained his Ph.D. in mathematical statistics from the University of Sydney in 1970 and taught at Macquarie University from 1970 to 1973 and at Monash University from 1973 to 1998. In 1998 he became a lecturer in statistics and in 2000 Professor of Mathematical Genetics at the University of Oxford. Professor Griffiths has been Emeritus Professor at the University of Oxford since 2011 and a member of the Royal Society since 2010. His field of research is population genetics, in particular diffusion processes, coalescence theory, gene phylogenies, and ancestral inference.

In his lecture Professor Griffiths explained that genes are transmitted in a random manner and therefore probability theory is used to model intra-species evolution. He surveyed some models (without giving technical details) and described the interactions between mathematics and population genetics. After presenting the famous Wright-Fisher model (which goes back to the 1930s), Robert Griffiths addressed the revolutionary way of looking at evolution introduced by Kingman in 1982: instead of looking forward in time, we look backward! DNA data became available in the last decades and statistics now plays a crucial role in determining the ancestral trees back in time. A stunning application is the identification of hotspots of recombination, where chromosomes are more likely to break on reproduction.

IN 2006 THE CRM LAUNCHED THE "GRANDES CONFÉRENCES" LECTURE SERIES, IN ORDER TO FULFIL THE EXPECTATIONS OF A PUBLIC WISHING TO UNDERSTAND IMPORTANT DEVELOPMENTS IN THE MATHEMATICAL SCIENCES. THE "GRANDES CONFÉRENCES" FEATURE OUTSTANDING LECTURERS ABLE TO CONVEY THE POWER AND BEAUTY OF MATHEMATICAL RESEARCH TO A WIDE AUDIENCE. IN 2013-2014 FOUR LECTURES WERE DELIVERED AT THE UNIVERSITÉ DE MONTRÉAL: "THE MATHEMATICS OF EVOLUTION" BY ROBERT GRIFFITHS (OCTOBER 9, 2013); "THE EVOLUTION OF COOPERATION: WHY WE NEED EACH OTHER TO SUCCEED" BY MARTIN NOWAK (NOVEMBER 6, 2013); "LA DÉCOUVERTE DES FRACTALES LISSES" BY VINCENT BORRELLI (FEBRUARY 13, 2014); AND "LA PRÉVISION DES GRANDES CATASTROPHES" BY FLORIN DIACU (MAY 9, 2014). THE READER WILL FIND BELOW SUMMARIES OF THESE FOUR LECTURES, ADAPTED FROM ARTICLES PUBLISHED BY SABIN LESSARD AND CHRISTIANE ROUSSEAU IN LE BULLETIN DU CRM. EACH OF THE LECTURES WAS ATTENDED BY HUNDREDS OF PERSONS OF VARIOUS BACKGROUNDS. THE REFRESHMENTS FOLLOWING THE LECTURES ALLOWED THEM TO ASK QUESTIONS, RENEW OLD ACQUAINTANCES, AND MEET OTHER PERSONS INTERESTED IN SCIENCE. THE "GRANDES CONFÉRENCES DU CRM" ARE UNDER THE STEWARDSHIP OF CHRISTIANE ROUSSEAU AND YVAN SAINT-AUBIN, BOTH FULL PROFESSORS AT THE DEPARTMENT OF MATHEMATICS AND STATISTICS OF THE UNIVERSITÉ DE MONTRÉAL.

ROBERT GRIFFITHS





## THE EVOLUTION OF COOPERATION: WHY WE NEED EACH OTHER TO SUCCEED

**Martin Nowak**  
(Harvard University)

Many problems that challenge us today can be traced back to a tension between what is good and desirable for society and what is good and desirable for an individual. This tension can be observed when global problems such as climate change, pollution, hunger, and overpopulation are considered. In his lecture Martin Nowak argued that cooperation, not competition, is the key to the evolution of complexity. He first showed how widespread cooperation is among living beings. Bacteria cooperate in order to ensure the survival of their species. Social insects such as ants and bees provide instances of eusociality, where each individual's behaviour is geared towards the good of its community. Human societies depend upon cooperation, from the good samaritan to the Japanese worker who agreed to clean up the Fukushima nuclear plant while saying that "only some of us can do this work, I am young and unmarried, and I think that it is my duty to help solve this problem." The cells of an organism cooperate by reproducing only when the time is right, and the breakdown of cooperation between cells causes cancer.

Martin Nowak continued his lecture by giving a mathematical definition of cooperation and introducing the famous prisoner's dilemma. Each prisoner may cooperate (while paying a cost denoted by C) or desert. On the other hand each prisoner will gain a prize denoted by B if all prisoners cooperate. Natural selection rests on the hypothesis that individuals "desert," but Professor Nowak described five mechanisms that could account for the evolution of cooperation in nature: direct reciprocity (which in varied guises can lead to cooperation under some conditions); indirect reciprocity (which can lead to social intelligence); social selection (modelled through spatial games or games on graphs); group selection; and parental selection. Both forms of reciprocity (direct and indirect) are essential to the understanding of the evolution of prosocial behaviours in humans, but it is indirect reciprocity that made us human since it led to social intelligence and human language. Martin Nowak concluded his fascinating lecture by stating that we must learn global cooperation and cooperation for the sake of future generations.

## LA DÉCOUVERTE DES FRACTALES LISSES

**Vincent Borrelli**  
(Université Claude Bernard-Lyon 1)

In his lecture Professor Vincent Borrelli shared with his audience the great adventure in which he took part, namely, the discovery of smooth fractals. We all know the flat torus, which Professor Borelli illustrated by pointing to Pac-Man's world: if Pac-Man leaves his square on the left he reappears on the right and if he leaves the square at the top his head reappears at the bottom. Now let us consider the geometric torus, which looks like a donut or a buoy. We try to build one by gluing together two opposite sides of a sheet of paper, thus making a cylinder. So far we don't run into any problem. If we try to glue together the two ends of the cylinder in order to make a torus, however, we realize that it cannot be done without crumpling the paper. A transformation without "crumpling" is called an isometric transformation of the flat torus into a geometric torus. The existence of such an isometry (or the lack of it) is a deep mathematical question. John Nash, who was at the time a young mathematician and later won the Nobel Prize in Economics, proved that there exists an isometry between the flat torus and the geometric torus. Although the Nash-Kuiper theorem states that there actually exists a C1 isometry between the flat torus and the geometric torus, it does not enable one to visualize the resulting surface, which includes an infinite number of curvature breakpoints.

The great mathematician Mikhail Gromov became interested in this topic and developed a very powerful tool, called convex integration, that allows the theorem of Nash-Kuiper to be proved in a different manner. In this case also, the proof cannot be used to visualize the resulting surface. Gromov's book ("Partial differential relations") gives the key to an effective construction of the surface. In 2007 a team consisting of Vincent Borrelli, Francis Lazarus, Boris Thibert, and Saïd Jebrane tackled the problem of visualizing an embedding of the flat torus into 3-dimensional space. This large-scale project, joined somewhat later by Damien Rohmer, lasted until 2012. It was based on the following technique: the images of horizontal (resp. vertical) lines on the flat torus are the parallels (resp. meridians) of the geometric torus. The distances between points are not preserved under this transformation. Hence one starts by "processing" a smaller torus on which parallels and meridians are shorter than on the flat torus. One then adds thickenings (corrugations) that allow one to correct the discrepancies in distances. Although this idea is simple, its implementation is difficult and the computation of the surface required the use of several powerful computers.

Vincent Borrelli then showed his audience some internal and external "nooks" of the resulting surface (thanks to many zooms). This surface reminds one of fractals but is not actually a fractal: it is an instance of a new class of geometrical objects called "smooth fractals." The audience was delighted with this wonderful lecture and asked Professor Borrelli many questions, first in the lecture hall and then in the area where refreshments were served.



## LA PRÉVISION DES GRANDES CATASTROPHES Florin Diacu (University of Victoria)

On May 9, 2014, a half-day of activities centered on mathematics ("Essential mathematics") took place in the André-Aisenstadt pavilion. This event was organized by the  $\text{ncm}_2$  (a network of research centres that includes the CRM). A "Grande Conférence du CRM" was delivered by Florin Diacu during that time: it was based on the book "Megadisasters: The Science of Predicting the Next Catastrophe," written by the lecturer himself. In his lecture Professor Diacu discussed the kind of predictions that one can make for eight types of catastrophes: tsunamis, earthquakes, volcanic eruptions, hurricanes, rapid climate changes, collisions with asteroids or comets, stock market crashes, and pandemics. He also discussed what cannot be predicted about these. Florin Diacu stated that he became interested in this topic right after the 2004 tsunami in Indonesia.

On the sea shore the arrival of a tsunami (a solitary wave also called soliton) can be predicted by some signs. The phenomenon of solitary waves was discovered by John Scott Russell, a Scottish engineer, when he followed over many kilometers a wave that was propagating in a canal with no change in shape or speed. Harbingers of a tsunami, such as the ebbing of the sea, its bubbling, its odour of petrol or rotten eggs, allow the population to run away and find refuge on high ground. The propagation speed of a tsunami following an earthquake can be estimated using the depth of the sea; zones at risk can then be evacuated. Solitary waves, however, have elastic shocks and dispatching a counter-wave cannot protect people from a tsunami. Florin Diacu then addressed the problem of earthquakes. Their occurrence cannot be predicted exactly but one can determine time lapses when the probability of an earthquake is relatively high. As for hurricanes, meteorologists try to predict their trajectories and intensities, in order for the affected populations to protect themselves or leave the area. Some hurricanes "play tricks" on meteorologists: for instance hurricane Elena (in 1985) almost turned around on itself.

Florin Diacu also discussed climate change. The cyclical variations in the parameters of the Earth's orbit (eccentricity, inclination of the Earth's axis, etc.), caused by the attraction of the other planets, are called Milankovitch cycles. To a great extent they explain the past cycles in the Earth's climate. In order to predict climate change, meteorologists model the climate and carry out numerical simulations based

on their models. Climate modelling amounts to eliminating the random effects of meteorological forecasts so that only important trends are retained. Professor Diacu showed how the current observations and simulations support the global warming hypothesis. One of Florin Diacu's research areas is celestial mechanics and he devoted part of his lecture to the prediction and prevention of collisions with comets or asteroids. He described the monitoring, under the Space Watch program, of the celestial objects that pass by the Earth. This program also evaluates science-fiction-like means to protect the Earth from celestial objects. He concluded his lecture by talking about the prevention of stock market crashes, whose prediction can be made more precise by some indicators (including an indicator proposed by Robert Shiller, who was awarded the Nobel Prize in Economics).

## COLLOQUIA

The CRM, in collaboration with the Institut des sciences mathématiques (ISM), which coordinates graduate courses in mathematics in Québec, and an operations research centre (GERAD), organizes two series of seminars, one in mathematics and the other in statistics. These colloquia include survey talks by world-renowned mathematicians and statisticians and address topics at the leading edge of mathematical research.



FLORIN DIACU



## Le colloque CRM-ISM de mathématiques

In 2013–2014 the colloquium coordinators were François Bergeron (UQAM) and Andrew Granville (Université de Montréal).

**September 20, 2013**

**SVETLANA JITOMIRSKAYA** (University of California, Irvine)  
Quasiperiodic Schrödinger operators

**October 18, 2013**

**RAM MURTY** (Queen's University)  
The Sato–Tate conjecture

**October 25, 2013**

**FRANÇOIS LALONDE** (Université de Montréal)  
Un survol élémentaire de la topologie symplectique sans homologie de Floer et sans théorie de jauge

**November 15, 2013**

**HENRI GILLET** (University of Illinois at Chicago)  
Singular (arithmetic) Riemann–Roch revisited

**November 22, 2013**

**JEREMY QUASTEL** (University of Toronto)  
Exact formulas in random growth

**November 29, 2013**

**MICHAEL GEKHTMAN** (University of Notre Dame)  
Higher pentagram maps via cluster mutations and networks on surfaces

**December 13, 2013**

**YUJI KODAMA** (Ohio State University)  
Combinatorics and geometry of KP solitons and application to tsunami

**January 17, 2014**

**BORIS KHESIN** (University of Toronto)  
Nondegenerate curves and pentagram maps

**February 7, 2014**

**CHARLES EPSTEIN** (University of Pennsylvania)  
Degenerate diffusions arising in population genetics

**February 14, 2014**

**VINCENT BORRELLI** (Université Claude Bernard–Lyon 1)  
Tors plats en 3D

**March 14, 2014**

**DIMITRIS KOUKOULOPOULOS** (Université de Montréal)  
Pretentious multiplicative functions

**March 21, 2014**

**JAMES MAYNARD** (Université de Montréal)  
Small gaps between primes

**April 4, 2014**

**CATHERINE SULEM** (University of Toronto)  
Interaction between internal and surface waves in a two layers fluid

**April 11, 2014**

**ALEXEY KOKOTOV** (Université Concordia)  
Flat surfaces and determinants of Laplacians

**May 2, 2014**

**ERIC URBAN** (Columbia University)  
Eigenvarieties

## Le colloque CRM-ISM-GERAD de statistique

In 2013–2014 the colloquium coordinators were Debbie Dupuis (HEC Montréal), José Garrido (Concordia), and Christian Genest (McGill).

**September 27, 2013**

**LEN STEFANSKI** (North Carolina State University)  
Measurement error and variable selection in parametric and nonparametric models

**October 25, 2013**

**LUKE BORNN** (Harvard University)  
XY – Basketball meets Big Data

**November 29, 2013**

**MARC HALLIN** (Université Libre de Bruxelles and Princeton University)  
Signal detection in high dimension: testing sphericity against spiked alternatives

**December 6, 2013**

**STEPHEN M. STIGLER**  
Great probabilists publish posthumously

**January 24, 2014**

**DEREK BINGHAM** (Simon Fraser University)  
Calibration of computer experiments with large data structures

**February 28, 2014**

**CHRISTIAN P. ROBERT** (Université Paris–Dauphine)  
ABC as the new empirical Bayes approach?

**March 21, 2014**

**EDWARD FREES** (Wisconsin School of Business)  
Insurance company operations and dependence modeling

**April 11, 2014**

**RYAN TIBSHIRANI** (Carnegie Mellon University)  
Adaptive piecewise polynomial estimation via trend filtering



# THE CRM LABORATORIES

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*ONE OF THE MOST IMPORTANT CHARACTERISTICS OF THE CRM (AND ONE SHARED BY ONLY A FEW WORLD-CLASS INSTITUTES) IS ITS DUAL NATURE: THE CRM IS AT THE SAME TIME A COLLABORATIVE AND THEMATIC RESOURCE AND A CLUSTER OF NINE RESEARCH LABORATORIES. THUS ONE FINDS IN THE CRM A COMBINATION OF TWO MODELS: THE CLASSICAL MODEL (I.E., AN INSTITUTE WITH A STABLE MEMBERSHIP) AND THE THEMATIC MODEL (I.E., AN INSTITUTE THAT ORGANIZES THEMATIC PROGRAMMES AND GATHERS RESEARCHERS FROM ALL OVER THE WORLD AROUND THESE PROGRAMMES).*

*THE CRM LABORATORIES ARE FOCAL POINTS FOR THE LOCAL SCIENTIFIC ACTIVITY AND TAKE AN ACTIVE PART IN THE SCIENTIFIC PROGRAMMES OF THE CRM. THE MEMBERS OF LABORATORIES ORGANIZE THEMATIC YEARS OR SEMESTERS AND ACTIVITIES AND SEMINARS SPONSORED BY THE LABORATORIES THEMSELVES; THEY TRAIN GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS. EACH LABORATORY INCLUDES MEMBERS FROM SEVERAL UNIVERSITIES AND PROMOTES THE COLLABORATION BETWEEN RESEARCHERS FROM DIVERSE INSTITUTIONS.*

## MATHEMATICAL ANALYSIS

At the same time classical and central to modern mathematics, analysis involves the study of continuous systems, from dynamical systems to solutions of partial differential equations and spectra of operators. In 2013–2014 the Laboratory included 31 regular and 10 associate members working at 13 different universities in Canada, the United Kingdom, France, and Austria. The members of the Laboratory work in the following areas: harmonic analysis, complex analysis, several complex variables, potential theory, functional analysis, Banach algebras, microlocal analysis, analysis on manifolds, nonsmooth analysis, spectral theory, partial differential equations, geometric analysis, ergodic theory and dynamical systems, control theory, mathematical physics, applied mathematics, probability, nonlinear analysis, nonlinear differential equations, topological methods in differential equations, fluid dynamics, and turbulence.

### HIGHLIGHTS

In 2013–2014 the Analysis Laboratory created a new series of lectures (the Nirenberg Lectures), named in honour of Louis Nirenberg, an outstanding mathematician and professor at the Courant Institute (New York University). Louis Nirenberg is one of the foremost experts of our time in geometric analysis. The first group of lectures were delivered by Alessio Figalli (University of Texas at Austin) from May 13 to 16, 2014. The topic of these lectures was a collection of stability results for geometric and functional inequalities.

Among the highlights of this year we mention a programme organized by a member of the Analysis Laboratory, Vojkan Jakšić, on “recent developments in mathematical physics.” This programme had two goals: to train undergraduate and graduate students and postdoctoral fellows; and to gather leaders in the field in order to stimulate their research. The programme consisted of courses and seminars (each of which lasting 2 or 3 hours) and included a course or seminar almost every day between May 6, 2014, and August 1, 2014. The programme took place at McGill University and was organized by Vojkan Jakšić (McGill), Robert Seiringer (Institute of Science and Technology Austria), Armen Shirikyan (Cergy–Pontoise), and Annalisa Panati (Toulon–Var). It was sponsored by the Agence nationale de la recherche (France), le Conseil national de la recherche scientifique (France), the CRM, and NSERC.



## SEMINARS

The members of the Analysis Laboratory organize several seminars: the Nonlinear Analysis Seminar, the Joint McGill-Concordia Analysis Seminar, the Analysis Seminar at Université Laval, the Montreal Analysis Seminar, and the Spectral Analysis Seminar.

## STUDENTS AND POSTDOCTORAL FELLOWS

In 2013–2014 the members of the Analysis Laboratory supervised or cosupervised one undergraduate student, 45 M.Sc. Students, 38 Ph.D. Students, and 20 postdoctoral fellows.

## DIRECTOR

- Dmitry Jakobson (McGill)

## REGULAR MEMBERS

- Marlène Frigon, Paul M. Gauthier, Iosif Polterovich, Christiane Rousseau, Dana Schlomiuk (Université de Montréal)
- Stephen W. Drury, Vojkan Jakšić, Ivo Klemes, Paul Koosis, John A. Toth (McGill)
- Abraham Boyarsky, Galia Dafni, Pawel Góra, Alexey Kokotov, Alexander Shnirelman, Alina Stancu, Ron J. Stern (Concordia)
- Line Baribeau, Alexandre Girouard, Frédéric Gourdeau, Javad Mashreghi, Thomas J. Ransford, Jérémie Rostand (Laval)
- Tomasz Kaczinski (Université de Sherbrooke)
- Dominic Rochon (UQTR)
- Vadim Kaimanovich (Université d'Ottawa)
- Francis H. Clarke (Lyon 1)
- Donald A. Dawson (Carleton)
- Richard Fournier (Dawson College)
- Robert Seiringer (Institute of Science and Technology Austria)

## ASSOCIATE MEMBERS

- Octav Cornea, Richard Duncan, Samuel Zaidman (Université de Montréal)
- Kohur Gowrisankaran, Pengfei Guan, Niky Kamran (McGill)
- John Harnad, Dmitry Korotkin (Concordia)
- Nilima Nigam (Simon Fraser)
- Yiannis Petridis (University College, London)

## CICMA

### CENTRE INTERUNIVERSITAIRE EN CALCUL MATHÉMATIQUE ALGÈBRE

CICMA includes researchers working in number theory, group theory, and algebraic geometry. Algebraic geometry is a broad discipline having close links with diverse fields from arithmetic to theoretical physics. Eyal Goren and Adrian Iovita are leaders in the application of techniques from algebraic geometry to problems arising in number theory, especially Shimura varieties and p-adic cohomology theories. John McKay is one of the instigators of the moonshine programme, which ties together in a surprising way certain notions in the theory of modular forms, arithmetic geometry, and theoretical physics.

Number theory has developed over the last decades following two major trends: on one hand algebraic number theory, including such themes as the study of special values of L-functions attached to arithmetic objects, which originates in the work of Gauss and Dirichlet and leads to the modern conjectures of Deligne, Beilinson, and Bloch-Kato. Another theme of algebraic number theory, originating in the Langlands programme, postulates a close link between arithmetic L-functions and automorphic representations.

On the other hand analytic number theory addresses deep and subtle questions concerning the distribution of primes. It makes use of mathematical analysis techniques, especially functions of several complex variables and spectral theory. Number theory in all its different flavours is particularly well represented in the laboratory, with Darmon, Goren, Iovita, and Kassaei on the arithmetic and automorphic side, and David, Granville, Kisilevsky, Koukoulopoulos, and Lalin on the more analytic side of the subject.

## HIGHLIGHTS

In 2013–2014 James Maynard, a postdoctoral fellow supervised by Andrew Granville at the Université de Montréal, improved Yitang Zhang's results on the gaps between consecutive prime numbers. In March 2014 Chantal David was a plenary speaker at the prestigious "Arizona Winter School," where she gave a mini-course on her work on finite fields and the zeta functions associated with them. Adrian Iovita's research on p-adic families of Siegel modular forms were published as an article of more than 60 pages in the "Annals of Mathematics." In August 2013 Payman Kassaei's work on the conjecture of Artin on totally real fields was published in the "Journal of the AMS." In May 2014 Payman Kassaei also organized a particularly successful event, the Bellairs workshop on the Taylor-Wiles method applied to coherent cohomology. World leaders in this area (including Frank Calegari, Peter Scholze, and Jack Thorne) took part in the Bellairs workshop.



#### SEMINARS

The members of CICMA organize the Analytic Number Theory Seminar and the Québec-Vermont Number Theory Seminar.

#### STUDENTS AND POSTDOCTORAL FELLOWS

In 2013–2014 the members of CICMA supervised or cosupervised one undergraduate student, 24 M.Sc. students, 42 Ph.D. students, and 17 postdoctoral fellows.

#### DIRECTOR

- Henri Darmon (McGill)

#### REGULAR MEMBERS

- Andrew Granville, Dimitris Koukoulopoulos, Matilde Lalín (Université de Montréal)
- Eyal Z. Goren, Payman L. Kassaei, John Labute, Michael Makkai, Peter Russell (McGill)
- Chris J. Cummins, Chantal David, David Ford, Adrian Iovita, Hershy Kisilevsky, John McKay, Francisco Thaine (Concordia)
- Hugo Chapdelaine, Jean-Marie De Koninck, Claude Levesque (Laval)
- Damien Roy (University of Ottawa)
- David S. Dummit (University of Vermont)
- Ram Murty (Queen's University)

#### ASSOCIATE MEMBER

- Maksym Radziwill (Stanford)

## CIRGET

### CENTRE INTERUNIVERSITAIRE DE RECHERCHES EN GÉOMÉTRIE ET TOPOLOGIE

Topology and differential geometry are fundamental disciplines of mathematics whose richness and vitality, evident throughout history, reflect a deep link to our experience of the universe. They are a focal point of modern mathematics and indeed several domains of mathematics have recently shown a strong trend towards a geometrization of ideas and methods: two cases in point are mathematical physics and number theory.

CIRGET, based at UQAM, is composed of 17 regular members, 4 associate members, and a large number of postdoctoral fellows and graduate students working in this broad field. The main themes to be pursued in the coming years include the topological classification of 3-dimensional manifolds; the quantization of Hitchin systems and the geometric Langlands program; the classification of special Kähler metrics; the study of symplectic invariants, especially in dimension 4; nonlinear partial differential equations in Riemannian geometry, convex geometry, and general relativity; and Hamiltonian dynamical systems. Two further domains are represented within CIRGET: algebraic geometry (through Steven Lu's and Peter Russell's work) and geometric group theory (through Daniel Wise's work).

#### HIGHLIGHTS

CIRGET is very proud that one of its members, Professor Niky Kamran, has been awarded the 2014 CRM–Fields–PIMS Prize for his exceptional contributions to mathematics. Professor Kamran, who is an outstanding speaker, has published more than 125 scientific articles, surveys, and monographs. Another CIRGET member, André Joyal, has retired and is now Emeritus Professor at UQAM.

#### SEMINARS

CIRGET members organize the Geometry and Topology Seminar and the Symplectic Topology Seminar.

#### STUDENTS AND POSTDOCTORAL FELLOWS

In 2013–2014 the CIRGET members supervised or cosupervised one undergraduate student, 37 M.Sc. students, 37 Ph.D. students, and 30 postdoctoral fellows.

#### DIRECTOR

- Steven Boyer (UQAM)

#### REGULAR MEMBERS

- Abraham Broer, Octav Cornea, François Lalonde, Iosif Polterovich (Université de Montréal)
- Vestislav Apostolov, Olivier Collin, André Joyal, Steven Lu, Frédéric Rochon (UQAM)
- Pengfei Guan, Jacques Hurtubise, Niky Kamran, Peter Russell, Johannes Walcher, Daniel T. Wise (McGill)
- Virginie Charette (Université de Sherbrooke)

#### ASSOCIATE MEMBERS

- Dmitry Jakobson, John A. Toth (McGill)
- Syed Twareque Ali, John Harnad (Concordia)





## GIREF

### GROUPE INTERDISCIPLINAIRE DE RECHERCHE EN ÉLÉMENTS FINIS

The recent advances in computer hardware and software allow researchers to model and simulate physical phenomena whose complexity is unheard of. These problems are characterized by nonlinear laws, non-differentiable friction laws, large-deformation geometries, complex solid-solid or fluid-solid interactions, problems in multiphysics, etc. Such problems can be found everywhere in industrial environments, especially in the design and fabrication of high-technology products. Hence the members of GIREF (an acronym that means "Interdisciplinary Research Group in Finite Element Methods") aim to develop original numerical methods for solving cutting-edge industrial problems in nonlinear mechanics. Their work concern pure mathematics, computer science, software engineering, and engineering. The GIREF members propose general methods that can be used for diverse industrial applications. The 28 members of GIREF reflect the interdisciplinary nature of the laboratory and are based at Université Laval and the École Polytechnique de Montréal, as well as the Universities of Moncton, Ottawa, and Alberta.

#### HIGHLIGHTS

In June 2013 GIREF organized the Annual Meeting of the Canadian Applied and Industrial Mathematics Society (CAIMS), which gathered more than 200 participants in Québec City. Around the end of 2013 the software developed by GIREF and the Michelin company became the official Michelin software used in all its validation tests for new tires. This software is the outcome of almost ten years of work.

#### STUDENTS AND POSTDOCTORAL FELLOWS

In 2013–2014 the GIREF members supervised or cosupervised one undergraduate student, 7 M.Sc. students, 14 Ph.D. students, and 4 postdoctoral fellows.

#### DIRECTOR

- André Fortin (Laval)

#### REGULAR MEMBERS

- Michel Delfour (Université de Montréal)
- André Garon, Dominique Pelletier (École Polytechnique de Montréal)
- Jean-Philippe Lessard, José Manuel Urquiza (Laval)

#### ASSOCIATE MEMBERS

- Stéphane Etienne, François Guibault (École Polytechnique de Montréal)
- Abdelkader Baggag, Alain Cloutier, Marie-Laure Dano, Claire Deschênes, Nicolas Doyon, Guy Dumas, Michel Fortin, Yves Fortin, Robert Guénette, Hassan Manouzi, Jean-Loup Robert, René Therrien (Laval)
- Marie-Isabelle Farinas (UQAC)
- Yves Secrétan (INRS-ETE)
- Pierre Blanchet (Forintek Canada)
- Jean-François Héту (Conseil national de recherches Canada)
- Yves Bourgault (Université d'Ottawa)
- Mohamed Farhloul (Moncton)
- Pietro-Luciano Buono (University of Ontario Institute of Technology)
- Youssef Belhamadia (University of Alberta)

## LACIM

### LABORATOIRE DE COMBINATOIRE ET D'INFORMATIQUE MATHÉMATIQUE

LaCIM (French acronym meaning "Combinatorics and Mathematical Informatics Laboratory") is home to mathematics and theoretical computer science researchers whose interests comprise discrete mathematics and the mathematical aspects of computer science. Founded in 1989, LaCIM includes 16 regular members (of whom 9 are UQAM professors) and one associate member. It welcomes postdoctoral fellows and its regular members supervise or cosupervise many M.Sc. and Ph.D. students, as well as undergraduate and cegep summer research students. Many renowned mathematicians visit LaCIM and collaborate with its members in the following areas: enumerative and bijective combinatorics, theory of species, algebraic combinatorics, combinatorics of finite and infinite words, discrete geometry, theory of languages and automata, Gray codes, bioinformatics and genomics, and combinatorial optimization.

#### HIGHLIGHTS

In July 2013 LaCIM organized the « Words, Codes and Algebraic Combinatorics » conference in honour of Christophe Reutenauer's 60th birthday. The goal of this conference was to explore the close links between algebra, combinatorics, and theoretical computer science. In 2013–2014 many international visitors made long or short visits at LaCIM, thanks to LIRCO (a "Laboratoire International Associé" within CNRS). LIRCO includes French and Québec mathematicians: its French core is at the LaBRI in Bordeaux and its Québec core at LaCIM.

#### SEMINAR

Each week the Combinatorics and Theoretical Computer Science Seminar gathers the LaCIM members, students, and postdoctoral fellows for a lecture given by a visitor or a researcher from Montréal.

#### STUDENTS AND POSTDOCTORAL FELLOWS

In 2013–2014 the LaCIM members supervised or cosupervised 25 M.Sc. students, 22 Ph.D. students, and 12 postdoctoral fellows.

#### DIRECTOR

- François Bergeron (UQAM)

#### REGULAR MEMBERS

- Sylvie Hamel (Université de Montréal)
- Anne Bergeron, Srećko Brlek, Christophe Hohlweg, Gilbert Labelle, Vladimir Makarenkov, Christophe Reutenauer, Franco Saliola, Timothy Walsh (UQAM)
- Ibrahim Assem, Thomas Brüstle, Shingping Liu (Université de Sherbrooke)
- Benoît Larose (Champlain Regional College)
- Cédric Chauve, Marni Mishna (Simon Fraser)

#### ASSOCIATE MEMBER

- Nantel Bergeron (York University)

A portrait of Adam Oberman, a man with short dark hair, smiling. The name "ADAM OBERMAN" is written in white capital letters across the bottom left of the photo.

ADAM OBERMAN

## APPLIED MATHEMATICS

The Applied Mathematics Laboratory is a research network of 22 applied mathematicians, engineers, computer scientists, and chemists, based in Montréal. The laboratory exists primarily to stimulate research and collaboration in the applied mathematical research areas of its members by fostering discussion and the creation of ideas through conferences, workshops, and seminars, and the furtherance of research through its visitors' program and the appointment of talented postdoctoral fellows. The laboratory is also very concerned with the training of young researchers and supports travel and conference attendance of its postdoctoral fellows.

The research interests of the laboratory members are quite diverse although there are a number of common threads that make interchange and collaboration both possible and fruitful. Active areas of research represented within the laboratory include, for example, the application of dynamical systems theory to complex phenomena, high-dimensional chaos, and biology. There is also an interest in numerical linear algebra and its applications, including the design, analysis, and implementation of effective computer algorithms. Amongst the membership one will also find expertise in numerical simulation, applied dynamical systems, quantum chemistry, turbulence, combustion, biomechanics, numerical methods in fluid mechanics and electromagnetism, hp-finite element methods, molecular dynamics, control, optimization, preconditioners, and large-scale eigenvalue problems.

### HIGHLIGHTS

The Applied Mathematics Laboratory has proposed to organize a CRM thematic semester in 2016. During that semester workshops will be held at the CRM, Université Laval, and the Courant Institute (New York University). The CRM has accepted this proposition. Also the laboratory has been given the status of a team ("équipe associée") by the INRIA for the period 2013–2014. This status will allow the laboratory to obtain funds for trips by researchers and students working in teams.

### SEMINAR

The laboratory members organize the CRM/McGill Applied Mathematics Seminar.

### STUDENTS AND POSTDOCTORAL FELLOWS

In 2013–2014 the members of the Applied Mathematics Laboratory supervised or cosupervised 17 M.Sc. students, 32 Ph.D. students, and 19 postdoctoral fellows.

### DIRECTOR

- Adam Oberman (McGill)

### REGULAR MEMBERS

- Jacques Bélair, Anne Bourlioux, Robert G. Owens (Université de Montréal)
- Peter Bartello, Peter Edwin Caines, Xiao-Wen Chang, Rustum Choksi, Antony R. Humphries, Jean-Christophe Nave, Bruce Shepherd, Gantumur Tsogtgerel, Adrian Vetta, Sherwin A. Maslowe, Eliot Fried, Jian-Jun Xu (McGill)
- Eusebius J. Doedel (Concordia)
- André D. Bandrauk (Université de Sherbrooke)
- Emmanuel Lorin de la Grandmaison (Carleton)

### ASSOCIATE MEMBERS

- Jean-Philippe Lessard (Laval)
- Nilima Nigam (Simon Fraser University)
- George Haller (ETH Zürich)

## MATHEMATICAL PHYSICS

The mathematical physics group is one of the oldest and most active at the CRM. It consists of 19 regular members, 10 local associate members (all full-time faculty members at one of the participating universities), and 8 external associate members working permanently at universities and research laboratories in Europe, the U.S., or Mexico. The group carries out research in many of the most active areas of mathematical physics: coherent nonlinear systems in fluids, optics, and plasmas; classical and quantum integrable systems; the spectral theory of random matrices; percolation phenomena; conformal field theory; quantum statistical mechanics; spectral and scattering theory of random Schrödinger operators; quasi-crystals; relativity; spectral transform methods; foundational questions in quantization; asymptotics of eigenstates; coherent states; wavelets; supersymmetry; the symmetry analysis of PDEs and difference equations; representation theory of Lie groups and quantum groups; and the mathematical structure of classical and quantum field theories.



JOHN HARNAD

### HIGHLIGHTS

In 2013–2014 Johannes Walcher organized activities at the CRM (see above) and was also one of the principal organizers of the thematic semester on Calabi-Yau manifolds at the Fields Institute (August–December 2013). Dmitry Korotkin and Peter Zograf organized a workshop at the Banff International Research Station (“Integrable Systems and Moduli Spaces,” from August 25 to 30, 2013). Jiří Patera coorganized the conference on « Symmetries of Discrete Systems and Processes » in the Czech Republic (July 15–19, 2013).

Six members of the Mathematical Physics Laboratory (Marco Bertola, Robert Brandenberger, John Harnad, Alexander Its, Alex Maloney, and Johannes Walcher) belong to the scientific committee preparing the CRM thematic semester on the AdS/CFT correspondence and integrability, which will be held from June to December 2015. Pavel Winternitz was awarded the Exceptional Publication Prize by the rector of the Czech Technological University for a book he wrote with Libor Snobl (“Classification and Identification of Lie Algebras”).

Alex Maloney was Visiting Professor at Harvard University in 2013–2014, was awarded a Simons Fellowship in Theoretical Physics (for the period September 1st, 2013–August 31, 2014), and was plenary speaker at the Canadian Conference on General Relativity and Relativistic Astrophysics (Winnipeg, May 21–23, 2014).

### SEMINARS

The laboratory members organize the Concordia Mathematical Physics Seminar, the Working Seminar in Mathematical Physics, and the Mathematical Physics Seminar.

### STUDENTS AND POSTDOCTORAL FELLOWS

In 2013–2014 the members of the Mathematical Physics Laboratory supervised or cosupervised 8 undergraduate students, 31 M.Sc. students, 44 Ph.D. students, and 24 postdoctoral fellows.

### DIRECTOR

- John Harnad (Concordia)

### REGULAR MEMBERS

- Véronique Hussin, Manu B. Paranjape, Jiří Patera, Yvan Sain-Aubin, Luc Vinet, Pavel Winternitz (Université de Montréal)
- Robert Brandenberger, Keshav DasGupta, Jacques Hurtubise, Alexander Maloney, Johannes Walcher (McGill)
- Syed Twareque Ali, Marco Bertola, Richard L. Hall, Dmitry Korotkin (Concordia)
- Pierre Mathieu (Laval)
- Vasilisa Shramchenko (Université de Sherbrooke)
- Alfred Michel Grundland (UQTR)

### ASSOCIATE MEMBERS

- Alexander J. Hariton, François Lalonde, Igor Loutsenko (Université de Montréal)
- Dmitry Jakobson, Vojkan Jakšić, Niky Kamran, John A. Toth (McGill)
- Chris J. Cummins, Alexander Shnirelman (Concordia)
- Stéphane Durand (Cégep Édouard-Montpetit)
- Robert Conte, Bertrand Eynard (CEA-Saclay)
- Jean-Pierre Gazeau (Paris 7)
- Alexander R. Its (Indiana University – Purdue University Indianapolis)
- Decio Levi (Università di Roma Tre)
- Robert Seiringer (Institute of Science and Technology Austria)
- Alexander Turbiner (UNAM, Mexico)
- Peter Zograf (Steklov Mathematical Institute, Saint Petersburg)

### PHYSNUM

Applied mathematics now plays an important role in the biomedical field and especially the neurosciences. The research activity at PhysNum (“Numerical Physics”) has two main themes: pharmacometrics and brain imaging. In particular Jean-Marc Lina and Habib Benali study the multimodal imaging of the spinal cord, Lina and Christophe Grova the multiresolution and multimodal imaging in magneto-electrophysiology, and Benali and Maxime Descoteaux models of the anatomical and functional connectivity of the brain. Grova also studies neurovascular models in epilepsy and Lina studies sparse representations, inverse problems, brain wave synchronization, and scale-invariant processes in electrophysiology.

Fahima Nekka and her team conduct research in pharmacometrics, a discipline whose goal is to interpret and describe pharmacological phenomena in a quantitative manner, so as to support rational therapeutic decisions and improvement of patient health. They have developed a whole framework of probabilistic pharmacometrics in which different sources of variability and the nonlinearity of the system are accounted for. The team is working on compliance metrics and ranking and on direct and inverse problems related to patient drug behaviour and the therapeutic effect of drugs. It is conceiving tools that shed new light on drug development and evaluation, revisiting classical concepts in pharmacology and developing models for drug interactions.

### HIGHLIGHTS

Jean-Marc Lina and Christophe Grova made use of information theory within a Bayesian inference formalism in order to propose a new approach for locating brain activity through electromagnetic measurements taken outside the skull. Their solution of the inverse problem in electromagnetic tomography is being used in clinical research carried out at the Montreal Neurological Institute (McGill) and was implemented in the Brainstorm software. In August 2014 the work of Lina and Grova was presented at the “19th International Conference on Biomagnetism.”



Maxime Descoteaux and Dr. David Fortin (from the Faculty of Medicine and Health Sciences at the Université de Sherbrooke) have been working for several years on the use of neurosurgery and diffusion MR imaging to explore the wiring of the brain. The combined use of surgery and imaging allows one to make brain surgery more precise. The medical imaging tools designed and tested by Descoteaux and Fortin have produced conclusive results as well as amazing anatomical images. Their work was mentioned in the special issue of the National Geographic magazine devoted to the brain.

In collaboration with Professor Jean Gotman (from the Montreal Neurological Institute) and Kais Gadhoumi (a Ph.D. student), Jean-Marc Lina studied the scale invariance of acquired intracerebral signals in patients suffering from epilepsy. This property was estimated through the formalism of dominant wavelet coefficients (introduced by Jaffard). They have been able to demonstrate that the scale exponent and the dispersion of this exponent (described by the multifractal spectrum) are characteristics that can be used to improve the prediction of epileptic seizures.

In April 2014 Fahima Nekka was awarded a new NSERC Industrial Chair in Pharmacometrics at the Université de Montréal.

#### **STUDENTS AND POSTDOCTORAL FELLOWS**

In 2013–2014 the members of PhysNum supervised or cosupervised 20 M.Sc. students, 31 Ph.D. students, and 13 postdoctoral fellows.

#### **DIRECTOR**

- Jean-Marc Lina (École de technologie supérieure)

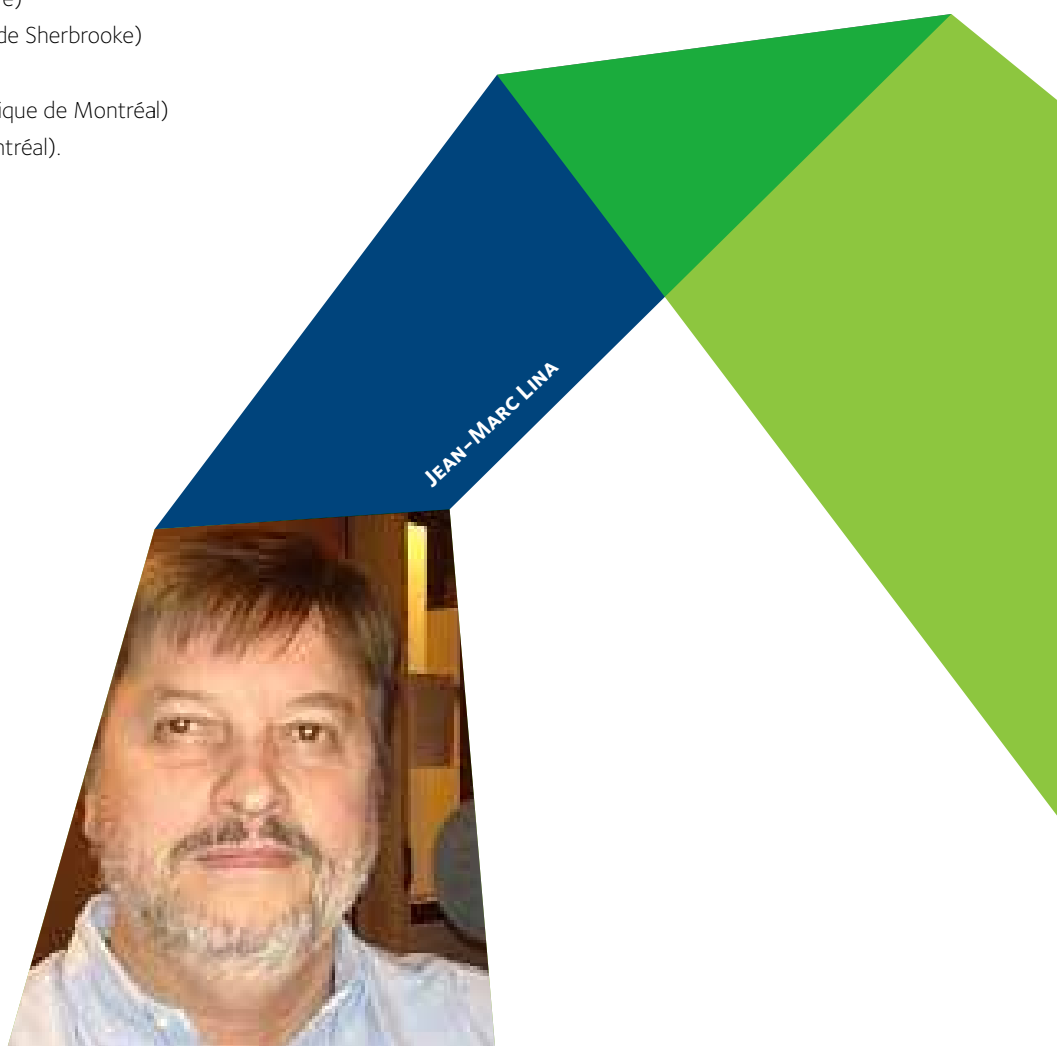
#### **REGULAR MEMBERS**

- Alain Arnéodo (UMR 5672, CNRS)
- Habib Benali (CHU Pitié Salpêtrière)
- Maxime Descoteaux (Université de Sherbrooke)
- Christophe Grova (Concordia)
- Frédéric Lesage (École Polytechnique de Montréal)
- Fahima Nekka (Université de Montréal).

## **STATISTICS**

Statistics is central to many endeavours in society. Be it through surveys from sampling, clinical trials to study various biomedical treatments, or the study of the survival of an animal population, statistical methodology can be found everywhere in science. Recently statistics has undergone a revolution in its techniques and approaches. This revolution has been driven by the need to analyze very large data sets and data with more complex structure, and by the advent of powerful computers. Statistical methodology is now addressing problems whose structure is very complex, such as the analysis of brain images or genome data, and new methodology (such as data mining) is being developed for large data sets. Note that the name of the laboratory must be interpreted broadly, as some of its members are actuaries, probabilists, or biostatisticians.

One of the aims of the laboratory is to structure the Québec statistical community so that it can participate in this revolution at a time when an important renewal of academic personnel is taking place. This structure allows the Québec community to participate in Canada-wide programs organized by the three Canadian mathematics institutes. The laboratory is formed of the leaders of the Québec school of statistics, who work on topics such as statistical learning and neural networks, survey sampling, analysis of functional data, statistical analysis of images, dependence structures, Bayesian analysis, analysis of time series and financial data, and resampling methods.



## HIGHLIGHTS

Members of the Statistics Laboratory organized the Workshop on Nonparametric Curve Smoothing, which took place on December 16 and 17, 2013, and was sponsored by the laboratory itself (see the section of the present report on Other Activities). During the year under consideration three members of the laboratory (Christian Genest, Louis-Paul Rivest, and Fateh Chebana) prepared the CRM-CANSSI Workshop on New Horizons in Copula Modeling, which took place from December 15 to 18, 2014. Recall that CANSSI is the Canadian Statistical Sciences Institute. This workshop was also sponsored by the Canada Research Chair in Stochastic Dependence Modeling.

In 2013–2014 many laboratory members were honoured or accepted positions of responsibility reflecting their competence and their reputation on the world scene. Here are three examples of such recognition. Yoshua Bengio was named Senior Fellow of the Canadian Institute for Advanced Research (CIFAR). Three members of the Statistics Laboratory (Masoud Asgharian, David Haziza, and Erica Moodie) became at the same time Associate Editors for the prestigious and influential Journal of the American Statistical Association (JASA). During the 2014 discovery grant competition Éric Marchand was Chair of the Statistics Section of the Mathematics and Statistics Evaluation Group.

## SEMINARS

The members of the Statistics Laboratory organize the CRM-ISM-GERAD Statistics Colloquium (mentioned above), the Montreal Seminar of Actuarial and Financial Mathematics, the McGill Statistics Seminar Series, and the Statistics Seminar of the Université de Sherbrooke.

## STUDENTS AND POSTDOCTORAL FELLOWS

In 2013–2014 the members of the Statistics Laboratory supervised or cosupervised 158 M.Sc. students, 103 Ph.D. students, and 25 postdoctoral fellows.

## DIRECTOR

- Christian Genest (McGill)

## REGULAR MEMBERS

- Jean-François Angers, Mylène Bédard, Yoshua Bengio, Martin Bilodeau, Pierre Duchesne, David Haziza, Pierre Lafaye de Micheaux, Christian Léger, Manuel Morales, Alejandro Murua, François Perron (Université de Montréal)
- Juli Atherton, Jean-Philippe Boucher, Mathieu Boudreault, Arthur Charpentier, Sorana Froda, Simon Guillotte, Fabrice Larribe, Geneviève Lefebvre, Brenda MacGibbon, Jean-François Renaud (UQAM)
- Masoud Asgharian, Abbas Khalili, Aurélie Labbe, Erica E. M. Moodie, Johanna Nešlehová, Robert W. Platt, James O. Ramsay, Russell Steele, David A. Stephens, David B. Wolfson (McGill)
- Yogendra P. Chaubey, José Garrido, Lea Popovic, Arusharka Sen, Wei Sun (Concordia)
- Belkacem Abdous, Anne-Sophie Charest, Thierry Duchesne, Lajmi Lakhel Chaieb, Louis-Paul Rivest (Laval)
- Taoufik Bouezmarni, Éric Marchand (Université de Sherbrooke)
- Nadia Ghazzali (UQTR)
- Debbie J. Dupuis, Bruno Rémillard (HEC Montréal)

## ASSOCIATE MEMBERS

- Vahid Partovi Nia (École Polytechnique de Montréal)
- Fateh Chebana (Institut national de la recherche scientifique, Québec)



CHRISTIAN GENEST

# THE CRM PRIZES

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*EACH YEAR THE CRM AWARDS FOUR PRIZES (AMONG THE EIGHT IMPORTANT NATIONAL PRIZES IN THE MATHEMATICAL SCIENCES): THE CRM-FIELDS-PIMS PRIZE (AWARDED JOINTLY BY THE THREE CANADIAN MATHEMATICS INSTITUTES); THE THEORETICAL PHYSICS PRIZE AWARDED JOINTLY BY THE CRM AND THE CANADIAN ASSOCIATION OF PHYSICISTS; THE CRM-SSC PRIZE, AWARDED JOINTLY BY THE CRM AND THE STATISTICAL SOCIETY OF CANADA TO A RESEARCHER AT THE BEGINNING OF HIS OR HER CAREER; AND THE ANDRÉ AISENSTADT PRIZE, AWARDED BY THE CRM TO A RISING YOUNG CANADIAN STAR SELECTED BY THE CRM INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE.*

## **THE 2014 CRM-FIELDS-PIMS PRIZE AWARDED TO NIKY KAMRAN**

Professor Kamran, from McGill University, has spent his career in Canada, working in the areas of analysis and differential geometry. His interests are far reaching, with the two main directions of his research being in the theory of exterior differential systems and Lie theory, a central area of the geometric analysis of systems of partial differential equations, and the mathematical analysis of general relativity.

Professor Kamran's work on the topic of exterior differential systems has its roots in the foundational insight of Élie Cartan, which describes local geometrical objects in terms of systems of differential forms that are invariant under diffeomorphisms and other infinite-dimensional Lie (pseudo) group actions. Professor Kamran's principal contributions have been in the theory of existence of solutions and the classification of infinite-dimensional symmetries. His publications on isotropy subgroups of transitive analytic Lie pseudogroups of infinite type are definitive, and involve global elements, such as the cohomology of certain differential complexes, and local ones, which for example include Malgrange's estimates arising from his proof of the Cartan-Kähler theorem.

Professor Kamran's contributions to the mathematical analysis of the Einstein equations of general relativity are extremely influential as well, in an area that is currently running as a "hot topic." His work, in a series of important papers with co-authors F. Finster, J. Smoller, and S.-T. Yau, addresses the basic question of stability of Lorentzian space-times, something that is fundamental to our understanding of present-day cosmology. The key in such questions about nonlinear systems of evolution equations is to understand on a deep level the solution operator for the linearized equations; Professor Kamran and his collaborators have given a systematic treatment of the "black-hole" space-times, namely of the Schwarzschild and Kerr solutions to Einstein's equations. His most recent work addresses the anti-deSitter solutions as the central object of interest in the approach to quantum gravity known as the Anti-deSitter/Conformal Field Theory correspondence.

Professor Kamran has published over 125 scientific articles. In addition he is a superb expositor and has contributed influential survey articles and monographs. His work is remarkable for its brilliant, original insights, in combination with a deep mathematical culture, representing a wide and varied range of topics of interest. Kamran's contributions will have a lasting scientific impact on Canadian mathematics and on the global mathematical community. The CRM is especially proud that Niky Kamran, a member of the CRM and the CIRGET laboratory, has been awarded the CRM-Fields-PIMS Prize.



## The CRM-Fields-PIMS Prize

This prize was established in 1994 as the CRM-Fields Prize to recognize exceptional research in the mathematical sciences. In 2005 PIMS became an equal partner in the awarding of the prize and its name was changed to the CRM-Fields-PIMS Prize. A committee appointed by the three institutes chooses the recipient. The previous recipients of the prize are H.S.M. (Donald) Coxeter (1995), George A. Elliott (1996), James Arthur (1997), Robert V. Moody (1998), Stephen A. Cook (1999), Israel Michael Sigal (2000), William T. Tutte (2001), John B. Friedlander (2002), John McKay (2003), Edwin Perkins (2003), Donald A. Dawson (2004), David Boyd (2005), Nicole Tomczak-Jaegermann (2006), Joel S. Feldman (2007), Allan Borodin (2008), Martin Barlow (2009), Gordon Slade (2010), Marc Lewis (2011), Stevo Todorčević (2012), and Bruce Reed (2013).

## THE 2014 ANDRÉ AISENSTADT PRIZE AWARDED TO SABIN CAUTIS

Dr. Sabin Cautis, from the University of British Columbia, is the recipient of the André Aisenstadt Prize for 2014. As an undergraduate student at the University of Waterloo, Dr. Cautis was a Putnam Fellow and a member of the winning team in the 1999 Putnam competition. After receiving a Bachelor of Mathematics degree in 2001, Sabin Cautis continued his education at Harvard University, where he obtained his Ph.D. in 2006 under the supervision of Joe Harris. Before joining the mathematics department at the University of British Columbia, Dr. Cautis was assistant professor at the University of Southern California and held postdoctoral positions at Columbia University, MSRI, and Rice University. In 2011–2013 he was a recipient of the highly coveted Alfred P. Sloan Fellowship.

Sabin Cautis works at the crossroads of algebraic geometry, representation theory, and low-dimensional topology. In his earlier work (joint with the 2011 André Aisenstadt Prize recipient, Joel Kamnitzer), he developed a new approach to Khovanov's knot invariants, which uses algebraic geometry and is inspired by mirror symmetry. Dr. Cautis is a world leader in the area of categorification. His results are expected to have a lasting impact on the field and lead to important developments in low-dimensional topology, the geometric Langlands program, and the mathematical aspects of quantum physics. In particular his recent work with Anthony Licata on categorification of Heisenberg algebras and vertex operators is a major step in the direction outlined by Igor Frenkel towards categorification of conformal field theory.

## The André Aisenstadt Prize

Created in 1991, the André Aisenstadt Mathematics Prize is intended to recognize and reward research achievements in pure and applied mathematics by talented young Canadian mathematicians. This prize consists of a \$3,000 award and a medal. The recipient is chosen by the International Scientific Advisory Committee of the CRM. At the time of consideration, candidates must be Canadian citizens or permanent residents of Canada and no more than seven years from their Ph.D. The mathematician who is awarded this prize is invited to give a lecture at the CRM and present a summary of his work (published in *Le Bulletin du CRM*). The previous recipients of the André Aisenstadt Prize are Niky Kamran (1992), Ian Putnam (1993), Michael Ward (1995), Nigel Higson (1995), Adrian S. Lewis (1996), Lisa Jeffrey (1997), Henri Darmon (1997), Boris Khesin (1998), John Toth (1999), Changfeng Gui (2000), Eckhard Meinrenken (2001), Jinyi Chen (2002), Alexander Brudnyi (2003), Vinayak Vatsal (2004), Ravi Vakil (2005), Iosif Polterovich (2006), Tai-Peng Tsai (2006), Alexander E. Holroyd (2007), Gregory G. Smith (2007), József Solymosi (2008), Jonathan Taylor (2008), Valentin Blomer (2009), Omer Angel (2010), Joel Kamnitzer (2011), Marco Gualtieri (2012), Young-Heon Kim (2012), and Spyros Alexakis (2013).



## THE 2014 CAP-CRM PRIZE AWARDED TO MARK VAN RAAMSDONK

The Canadian Association of Physicists (CAP) and the CRM awarded the 2014 CAP-CRM Prize in Theoretical and Mathematical Physics to Professor Mark Van Raamsdonk, from the University of British Columbia, for his highly original, influential contributions to several areas of theoretical physics, including string theory, quantum field theory, and quantum gravity. Through his work, he attempts to answer some of the deepest open questions in theoretical physics: What is space? What is time? How did our universe begin? How will it end? What is inside a black hole? Some of his most significant contributions include a study of actions governing the interactions of multiple D-branes (fundamental degrees of freedom in strongly coupled string theory) with gravitational and other classical fields, a discovery of UV-IR mixing in quantum field theories on noncommutative spacetime, and the first analytic study of deconfinement in a four-dimensional gauge theory. In 2008 his work led to a breakthrough in which the actions governing membranes (fundamental degrees of freedom in M-theory) were explicitly determined for the first time. More recently, he has been pioneering a new approach to understanding the origin of classical spacetime in quantum gravity using entanglement of the underlying degrees of freedom. Finally, throughout his career, he has made many novel contributions applying string theory to other areas of physics, from nuclear matter at high densities to properties of black holes.

Professor Van Raamsdonk received his B.Sc. from the University of British Columbia and his Ph.D. from Princeton University. He is currently a Professor in the Department of Physics at the University of British Columbia, where he has been since 2002. His work has been recognized by a Sloan Foundation Fellowship and a Canada Research Chair.

### The CAP-CRM Prize

The CRM and the Canadian Association of Physicists (CAP) created in 1995, on the occasion of the 50th anniversary of the CAP, a joint prize for recognizing exceptional achievements in theoretical and mathematical physics. The prize consists of a \$2,000 award and a medal. The previous recipients of the prize are Werner Israel (1995), William G. Unruh (1996), Ian Affleck (1997), J. Richard Bond (1998), David J. Rowe (1999), Gordon W. Semenoff (2000), André-Marie Tremblay (2001), Pavel Winternitz (2002), Matthew Choptuik (2003), Jiří Patera (2004), Robert Myers (2005), John Harnad (2006), Joel S. Feldman (2007), Richard Cleve (2008), Hong Guo (2009), Clifford Burgess (2010), Robert Brandenberger (2011), and Luc Vinet (2013).

MARK VAN RAAMSDONK



## THE 2014 CRM-SSC PRIZE AWARDED TO FANG YAO

The CRM and the Statistical Society of Canada have awarded the 2014 CRM-SSC Prize to Professor Fang Yao, from the University of Toronto. Fang Yao has conducted his most important research since arriving at the University of Toronto in 2006; it is both seminal and beautiful. Fang Yao received his B.Sc. from the University of Science and Technology in China. He was admitted as a graduate student to the University of California, Davis, where he completed both his M.Sc. and his Ph.D. in three years. He carried out his doctoral work under the joint supervision of Hans-Georg Müller and Jane-Ling Wang. After completing his Ph.D. in 2003, Fang Yao accepted a position in the Department of Statistics at Colorado State University. In 2006 he moved to the Department of Statistical Sciences at the University of Toronto, where he was promoted to the rank of Associate Professor with tenure in 2008. During his first sabbatical Fang Yao was invited to the Statistical and Applied Mathematical Sciences Institute in North Carolina as a Research Fellow. There he gave the opening address for a thematic programme and subsequently led one of the working groups during the fall term. For the rest of his sabbatical leave he moved on to UBC, where he created a new advanced graduate course, "Topics in Smoothing: Functional Data Analysis."

Professor Yao's expertise is in the area of functional data analysis (FDA), a relatively new field in statistical science that regards data as a set of functions. Fang's contributions to FDA have been fundamental. His research programme, characterized by great ambition and breadth, continues to lay the foundations of FDA by framing it in terms of interpretable models with complex correlation structures that improve the efficiency of inference techniques. Methods he develops are useful for both representation and regression problems, and are accessible through the development of his publicly available software PACE, which has significantly extended the impact of his research in statistical science and other fields. Fang Yao is the consummate statistician: he has a deep understanding of rigorous mathematical techniques, a broad statistical knowledge, and the ability to apply both in substantive problems.

Fang Yao has 30 peer-reviewed publications and is highly cited. His NSERC Discovery Grant increased substantially when it was renewed, and was coupled with a Discovery Accelerator Supplement. Professor Yao has made considerable contributions to the profession, particularly in supporting the development of research through his involvement in the organization of workshops, conferences, and programmes and through his commitment to the review of scholarly work. He is an Associate Editor for eight journals, including the Journal of the American Statistical Association, the Annals of Statistics, and the Canadian Journal of Statistics.

### The CRM-SSC Prize

The SSC, founded in 1977, is dedicated to the promotion of excellence in statistical research and practice. The prestigious CRM-SSC Prize is given each year to a Canadian statistician in recognition of outstanding contributions to the discipline during the recipient's first 15 years after earning a doctorate. The previous recipients of the CRM-SSC Prize are Christian Genest (1999), Robert J. Tibshirani (2000), Colleen D. Cutler (2001), Larry A. Wasserman (2002), Charmaine B. Dean (2003), Randy Sitter (2004), Jiahua Chen (2005), Jeffrey Rosenthal (2006), Richard Cook (2007), Paul Gustafson (2008), Hugh Chipman (2009), Grace Y. Yi (2010), Edward Susko (2011), Changbao Wu (2012), and Derek Bingham (2013).





# THE CRM AND MATHEMATICAL EDUCATION

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*THE MANDATE OF THE CRM IS TO FOSTER THE DEVELOPMENT OF RESEARCH IN THE MATHEMATICAL SCIENCES AT ALL LEVELS. FOR THE CRM THE TRAINING OF YOUNG RESEARCHERS, THE PROMOTION OF MATHEMATICAL RESEARCH, AND THE DEVELOPMENT OF MATHEMATICS TEACHING ARE VERY IMPORTANT ENDEAVOURS. THIS IS WHY THE CRM SUPPORTS (FINANCIALLY AND OTHERWISE) MANY ACTIVITIES AND PROGRAMMES IN THE AREA OF MATHEMATICAL EDUCATION AND TRAINING. A SUBSTANTIAL PART OF THE CRM ACTIVITIES ARE CARRIED OUT IN COLLABORATION WITH THE INSTITUT DES SCIENCES MATHÉMATIQUES (ISM), WHICH WAS CREATED IN 1991 AND HAS EIGHT PARTNERS: BISHOP'S UNIVERSITY, CONCORDIA UNIVERSITY, MCGILL UNIVERSITY, UNIVERSITÉ DE MONTRÉAL, UQAM, UQTR, UNIVERSITÉ DE SHERBROOKE, AND UNIVERSITÉ LAVAL. THE ISM IS FINANCED BY ITS PARTNERS AND THE QUÉBEC MINISTRY OF EDUCATION. THE ISM MISSION CONSISTS OF: COORDINATING AND HARMONIZING THE MATHEMATICS GRADUATE PROGRAMMES OF QUÉBEC UNIVERSITIES; FOSTERING EXCELLENCE IN TRAINING; SUPPORTING RESEARCH THROUGH SCHOLARSHIPS AND PRIZES; AND STIMULATING THE INTEREST OF YOUNG PEOPLE FOR THE MATHEMATICAL SCIENCES (IN PARTICULAR THROUGH THE DISSEMINATION OF MATHEMATICAL KNOWLEDGE AMONG TEACHERS, YOUNG PEOPLE, AND THE GENERAL PUBLIC).*

## CRM-ISM POSTDOCTORAL FELLOWSHIPS

The CRM-ISM Postdoctoral Fellowships allow promising young researchers to devote most of their time to their research work. These postdoctoral fellows are chosen in a rigorous and very competitive manner: only one applicant out of 40 is selected. The postdoctoral fellows play a crucial role in our universities, by collaborating with mature researchers, bringing new ideas from other great centres of mathematical research, and organizing working groups on cutting-edge topics.

## 2013-2014 POSTDOCTORAL FELLOWS

Here is the list of fellows, along with the institution and year of their Ph.D. We also give their research areas and the names of the mathematicians who supervise them at the CRM. Note that the first four fellows work in diverse fields not necessarily related to the 2013-2014 thematic programmes, while the last four are associated with these thematic programmes.

### DAVID BELIUS

*Ph.D.:* ETH Zürich (2013)

*Supervisors:* Louigi Addario-Berry (McGill) and Louis-Pierre Arguin (Université de Montréal)

*Research area:* probability theory, especially for studying discrete-type problems

### THOMAS BOTHNER

*Ph.D.:* Indiana University-Purdue University Indianapolis (2013)

*Supervisors:* Marco Bertola, John Harnad, and Dmitry Korotkin (all three from Concordia University)

*Research area:* theory of integrable systems

### MICHAEL BRANDENBURSKY

*Ph.D.:* Technion (2010)

*Supervisors:* Octav Cornea and François Lalonde (Université de Montréal) and Steven Boyer and Olivier Collin (UQAM)

*Research area:* geometry and topology

### JAMES MAYNARD

*Ph.D.:* University of Oxford (2013)

*Supervisor:* Andrew Granville (Université de Montréal)

*Research area:* analytic number theory



**YU-TING CHEN**

*Ph.D.*: University of British Columbia (2013)  
*Supervisors*: Louigi Addario-Berry (McGill), Sabin Lessard (Université de Montréal), and Lea Popovic (Concordia)  
*Research*: probability theory, stochastic processes, and mathematical biology

**DANIELE ROSSO**

*Ph.D.*: University of Chicago (2013)  
*Supervisors*: Erhard Neher and Alistair Savage (University of Ottawa) and Vijayanthi Chari (University of California, Riverside)  
*Research area*: representation theory of Lie groups

**RAJENDRAN VENKATESH**

*Ph.D.*: Chennai (2013)  
*Supervisors*: Erhard Neher and Alistair Savage (University of Ottawa) and Vijayanthi Chari (University of California, Riverside)  
*Research area*: representation theory of infinite-dimensional Lie algebras

**YUXIANG ZHANG**

*Ph.D.*: Memorial University (2012)  
*Supervisors*: Frithjof Lutscher (University of Ottawa) and Frédéric Guichard (McGill)  
*Research area*: mathematical ecology and epidemiology

## UNDERGRADUATE SUMMER SCHOLARSHIPS

In collaboration with the CRM and the ISM professors, the ISM awards summer scholarships to promising undergraduates who want to do research during the summer and plan to study mathematics at the graduate level. These undergraduates are supervised by postdoctoral fellows, who in general are supervising students for the first time. The reader will find below the list of the undergraduate scholars for the summer of 2013.

**ALEX DE SERRE ROTHNEY** (Bishop's)

Scholarship co-financed by Trevor Jones and Brad Willms  
*Supervisors*: Trevor Jones and Brad Willms  
*Topic*: Symmetric Toeplitz Matrix

**Nicholas Galbraith** (McGill)

Scholarship co-financed by Steven Boyer  
*Supervisor*: Jessica Banks  
*Topic*: Physical Knot Theory

**OLIVIER GINGRAS** (Université de Montréal)

Scholarship co-financed by Pavel Winternitz  
*Supervisor*: Danilo Riglioni  
*Topic*: Superintegrable systems

**SAMUEL LAFERRIÈRE** (McGill)

Scholarship co-financed by Frédéric Rochon  
*Supervisor*: Carl Tipler  
*Topic*: Riemann-Roch theorem on irregular surfaces

**THOMAS NG** (McGill)

Scholarship co-financed by Dmitry Jakobson  
*Supervisor*: Suresh Eswarathasan  
*Topic*: Spectrum and Eigenfunctions of Laplacian on Compact, Finite Area, and Infinite Area Hyperbolic Surfaces

**MANUELA PINEROS-RODRIGUEZ** (Université de Montréal)

Scholarship co-financed by Dimitris Koukoulopoulos  
*Supervisor*: Mariah Hamel  
*Topic*: Encryption, Factorization and Primality Testing Algorithms

**WILLIAM WRIGHT** (McGill)

Scholarship co-financed by Henri Darmon  
*Supervisor*: Miljan Brakovec  
*Topic*: Rational Points on Modular Elliptic Curves

**DONGLIANG ZHANG** (McGill)

Scholarship co-financed by David Stephens  
*Supervisor*: Will Astle  
*Topic*: Model Selection in Complex Settings

## SCIENTIFIC ACTIVITIES JOINTLY ORGANIZED OR SUPPORTED BY THE CRM AND THE ISM

The CRM and the ISM jointly organize or support several scientific activities. We have already mentioned the SMS ("Séminaire de mathématiques supérieures"), the CRM-ISM Mathematics Colloquium, and the CRM-ISM-GERAD Statistics Colloquium. The CRM also supported an ISM Graduate Student Conference (« Colloque panquébécois des étudiants de l'ISM »), which took place at Université Laval from May 16 to 18, 2014. The CRM and the ISM gave financial support to the 57th Congress of the Association mathématique du Québec, which took place on October 11-12, 2013 at the Royal Military College Saint-Jean. The CRM and the ISM publish jointly the Annales mathématiques du Québec, a showcase of the Québec mathematical community that has existed for more than three decades.

## PROMOTION OF THE MATHEMATICAL SCIENCES BY THE CRM AND THE ISM

The Accromath magazine, whose editor-in-chief is André Ross, is produced by the ISM and its production costs are paid in part by the CRM. The magazine has two issues per year and is distributed free of charge in all Québec high schools and cegeps. The goal of Accromath is to stimulate the high school and cegep teachers by providing them with material that is topical and up-to-date. Accromath consists of articles on the most recent developments in mathematics and their applications, as well as articles on the history of mathematics or links between mathematics and the arts. Accromath has been awarded several prizes (both for its contents and graphic design). The CRM and the ISM jointly support the « Sciences et mathématiques en action » programme (created by Professor Jean-Marie De Koninck) and the Association québécoise des jeux mathématiques.

## STUDENTS WHO OBTAINED THEIR PH.D. IN 2013-2014

The CRM members supervise a large number of graduate students. We now give information on the students supervised by CRM members who graduated in 2013-2014. The name of the student is followed by the name of his or her supervisor (or names of his or her supervisors). Some names may be missing from this list, because we have only included those that have been brought to our attention. Here is the list of students who obtained their Ph.D. in 2013-2014.

**SEYED SAEED AHMADI** (José Garrido and Patrice Gaillardetz)

**TANBIR AHMED** (Vašek Chvátal)

**MACIEJ AUGUSTYNIAK** (Manuel Morales and Mathieu Boudreault)

**LOUIS BEAUDET** (Thomas Brüstle)

**HADI BIGDELY** (Daniel T. Wise)

**NICOLAS BOULANGER-LEWANDOWSKI** (Yoshua Bengio)

**T. BRETMANN** (André D. Bandrauk)

**LUCA CANDELORI** (Henri Darmon)

**SYED CHOWDHURY** (Dmitry Korotkin and Syed Twareque Ali)

**GUILLAUME DESJARDINS** (Yoshua Bengio)

**MICHÈLE DESJARDINS** (Habib Benali and Frédéric Lesage)

**IBRAHIMA DIONE** (André Fortin and José Manuel Urquiza)

**ANDREW FIORI** (Eyal Z. Goren)

**CLEMENT GOMEZ** (Henri Darmon)

**EDGAR GUEVARA CODINA** (Frédéric Lesage)

**FEHMI JAAFAR** (Sylvie Hamel)

**MARTIN KLIMES** (Christiane Rousseau)

**SÉBASTIEN LABBÉ** (Srečko Brlek)

**VINCENT LAMOTHE** (Alfred Michel Grundland)

**SHUJIE LI** (David A. Stephens and James A. Hanley)

**ZHENYANG LI** (Pawel Góra and Abraham Boyarsky)

**KODJO ESSONANA MAGNANI** (Vasilisa Shramchenko and Ibrahim Assem)

**LENKA MOTLOCHOVÁ** (Jiří Patera)

**NDOUNÉ NDOUNÉ** (Vasilisa Shramchenko and Ibrahim Assem)

**NGOC AI VAN NGUYEN** (Damien Roy)

**JAMES PARKS** (Chantal David)

**JESUS ROGELIO PEREZ BUENDIA** (Adrian Iovita)

**MARCO ANTONIO PÉREZ BULLONES** (André Joyal)

**LISA POWERS** (Rustum Choksi and Jean-Christophe Nave)

**LOUIS-FRANÇOIS PRÉVILLE-RATELLE** (François Bergeron)

**SAMIR RAOUAFI** (Thomas J. Ransford)



**FELIX SALAZAR** (André Garon)

**BEHROUZ TAJI** (Peter Russell, Jacques Hurtubise, and Steven Shin-Yi Lu)

**LUIZ TAKEI** (Eyal Z. Goren and Henri Darmon)

**OLIVIER TREMBLAY SAVARD** (Nadia Sophie El-Mabrouk)

**BAOYONG WANG** (David Sankoff)

**MALIK YOUNSI** (Thomas J. Ransford)

**ROMAIN YVINEC** (Michael C. Mackey)

**YOUNES ZEROUALI** (Jean-Marc Lina)

## STUDENTS WHO OBTAINED THEIR M.Sc. IN 2013-2014

**ORLA AISLINN MURPHY** (Christian Genest and Johanna Nešlehová)

**LUDOVIC ALARIE-VÉZINA** (Pierre Mathieu)

**IBRAHIM AL-BALUSHI** (Gantumur Tsogtgerel)

**ADAM ALCOLADO** (Johannes Walcher)

**NOÉ AUBIN-CADOT** (François Lalonde)

**BENJAMIN BEAUREGARD** (Thierry Duchesne)

**SÉBASTIEN BERTRAND** (Alfred Michel Grundland)

**MARC-OLIVIER BILLETTE** (Alejandro Murua and Pierre Lafaye de Micheaux)

**CATHERINE BOURBEAU** (Christophe Hohlweg)

**RYAN BRADSHAW** (Damien Roy)

**CRYSTEL BUJOLD** (Andrew Granville)

**MARK BUMAGIN** (Stephen W. Drury)

**NICOLAS BUREAU** (Claude Levesque and Hugo Chapdelaine)

**ALEXANDRE CASTONGUAY** (Frédéric Lesage)

**HUITAIN CHEN** (Christian Genest and David A. Stephens)

**ANTOINE CORRIVEAU LA GRENADE** (Thomas J. Ransford)

**MARIE-PIER CÔTÉ** (Christian Genest)

**AUDREY DAGENAIS** (Thomas Brüstle)

**CHRISTOPHE DESJARDINS-MORRIS** (Niky Kamran)

**RABI FARES** (Wei Sun)

**MICHELE FORNEA** (Adrian Iovita)

**DOMINIK FRANCOEUR** (Virginie Charette)

**EHSSAN GHASHIM** (Éric Marchand)

**ASSIA GROIEZ** (Mylène Bédard)

**XIA GUAN** (Arusharka Sen)

**ALEXANDRE GUAY** (Thomas J. Ransford)

**CHRISTIAN HAUG-JOHANSEN** (Bruno Rémillard)

**TANGUY HEDRICH** (Christophe Grova)

**ANAELLE HERTZ** (Véronique Hussin)

**LIONEL KATSHINGU** (François Bergeron)

**OLIVIER LAMBERT** (Thomas Brüstle)

**PHILIPPE LAMONTAGNE** (Gilles Brassard and Alain Tapp)

**FRANÇOIS LANIEL** (Javad Mashregi)

**DAVID LAPIERRE** (Robert G. Owens)

**RÉBECCA LAPOINTE** (Alain Tapp)

**ROSEMONDE LAREAU DUSSAULT** (Virginie Charette)

**ALEXANDRE LEMIRE PAQUIN** (Eyal Z. Goren and Henri Darmon)

**JULIE LEWIS** (Hershey Kisilevsky)

**HOUDÉTÉ ODILON LOKO** (Thierry Duchesne)

**ERIKA MALDONADO** (Mathieu Boudreault)

**FRÉDÉRIC MORNEAU GUÉRIN** (Javad Mashregi)

**PATRICK MUNROE** (Dmitry Jakobson and John A. Toth)

**TUAN NGUYEN** (Alina Stancu)

**GIULIO ORECCHIA** (Adrian Iovita)

**CAMILO ORTIZ ASTORQUIZA** (Pawel Góra)

**OSCAR CAMILO ORTIZ ORTEGA** (Fabrice Larribe)

**JORDAN PAYETTE** (François Lalonde and Johannes Walcher)

**SÉBASTIEN PICARD** (Pengfei Guan)

**ALICE POZZI** (Adrian Iovita)

**FRANCESCO PULICE** (Manuel Morales)

**HUGO ROBERT** (Jean-François Renaud)

**VINCENT ROY** (Bruno Rémillard)

**ABDOLNASSER SADEGHKHANI** (Éric Marchand)

**LAMINE SAIDI** (Sabin Lessard)

**DAVID SHAUN-GUAY** (Bruno Rémillard)

**JULIANA SHULZ** (José Garrido)

**NICOLAS SIMARD** (Henri Darmon)

**PETER SLOAN** (Adrian Vetta)

**ERIC THIBODEAU-LAUFER** (Yoshua Bengio)

**VIET ANH TRAN** (Pierre Lafaye de Micheaux)

**JEAN-SÉBASTIEN TURCOTTE** (Louis-Pierre Arguin)

**CHRISTIAN TYE GINGRAS** (André Fortin)

**NICOLAS VIGNEAU-ROY** (Maxime Descoteaux)

# THE CRM PARTNERSHIPS

*ALTHOUGH THE CRM IS PRIMARILY CONCERNED WITH MATHEMATICAL RESEARCH AND TRAINING CONDUCTED WITHIN QUÉBEC, ITS ACTIVITIES ARE PART OF A BROAD FRAMEWORK AND IT COLLABORATES WITH MANY PARTNERS TO FULFILL ITS MISSION AND ENSURE THAT THE RESEARCH CARRIED OUT IN QUÉBEC IS OF INTERNATIONAL CALIBRE.*

## INTERNATIONAL PARTNERSHIPS

The CRM members have many fruitful collaborations with French researchers, in particular those working at the Centre national de la recherche scientifique (CNRS), the Institut national de recherche en informatique et automatique (INRIA), and the Institut national de la santé et de la recherche médicale (INSERM). The CRM has signed a formal agreement with the ALGANT consortium (Algebra, Geometry, Number Theory) within the Erasmus Mundus network of the European Union. This agreement stimulates exchanges and joint supervision of graduate students. In 2010 the CRM and eleven other partners signed an agreement for the exchange of researchers with SISSA (International School for Advanced Studies, in English), a graduate studies university based in Trieste, Italy. The CRM also has two formal agreements with the Tata Institute of Fundamental Research (TIFR), a prestigious Indian institution: an agreement with the TIFR Centre for Applicable Mathematics (in Bangalore) and another with the TIFR centre in Mumbai. Finally we mention that the National Science Foundation (NSF) of the United States provides some financial support for almost every thematic programme organized by the CRM.

## THE UNITÉ MIXTE INTERNATIONALE (UMI) OF THE CNRS AT THE CRM

A few years ago the Centre National de la Recherche Scientifique (CNRS) in France decided to create at the CRM a so-called UMI (i.e., a research unit outside France itself). The official name of this UMI is "Centre de recherches mathématiques – UMI 3457" and it was inaugurated in October 2011. Thanks to Laurent Habsieger, UMI co-director since 2011, this UMI has been extremely successful. The UMI supports financially long or short visits to the CRM by French researchers; it also supports visits to France by Québec researchers who spend a few weeks in France or are given temporary positions. The UMI provides financial support to meetings and workshops, either directly or through the reimbursement of the lecturers' expenses (for instance). In this manner the UMI supports the activities of the CRM thematic programmes and other activities.

LAURENT HABSieGER



## ACADEMIC PARTNERS

## COLLABORATIONS WITH RESEARCH NETWORKS

## COLLABORATIONS WITH PROFESSIONAL SOCIETIES

CRM





# THE PUBLICATIONS OF THE CRM

THE CRM PROVIDES ITS MEMBERS WITH AN EXCELLENT RESEARCH ENVIRONMENT, WHICH ENABLES THEM TO PUBLISH ARTICLES IN HIGH-CALIBRE INTERNATIONAL JOURNALS. THE CRM ALSO PUBLISHES ON ITS OWN MANY PROCEEDINGS, MONOGRAPHS, LECTURE NOTES, SOFTWARE PRODUCTS, VIDEOS, AND RESEARCH REPORTS. THE IN-HOUSE SERIES (LES PUBLICATIONS CRM) INCLUDES BOOKS IN ENGLISH OR FRENCH. THE CRM ALSO HAS AGREEMENTS WITH THE AMERICAN MATHEMATICAL SOCIETY (AMS) AND SPRINGER. THE AMS PUBLISHES TWO BOOK SERIES PRODUCED AT THE CRM (THE CRM MONOGRAPH SERIES AND THE CRM PROCEEDINGS & LECTURE NOTES, NOW CALLED CRM PROCEEDINGS AND INCLUDED IN THE CONTEMPORARY MATHEMATICS SERIES). IN THE SAME FASHION SPRINGER PUBLISHES THE CRM SERIES IN MATHEMATICAL PHYSICS. IN 2011 SPRINGER WAS ALSO PUBLISHING THE LECTURE NOTES IN STATISTICS (SUBSERIES CRM). THE UNIVERSITÉ DE MONTRÉAL PRESS PUBLISHES THE MONOGRAPHS WRITTEN BY THE AISENSTADT CHAIRHOLDERS. THE CRM ALSO HAS OCCASIONAL COLLABORATIONS WITH PUBLISHING HOUSES SUCH AS GAUTHIER-VILLARS, INTERNATIONAL PRESS, AND THE INSTITUTE OF MATHEMATICAL STATISTICS. FINALLY THE CRM HAS PRODUCED SEVERAL VIDEOS ON DIVERSE MATHEMATICAL TOPICS.

In 2013–2014 the *CRM Proceedings & Lecture Notes* were included in the *Contemporary Mathematics* series. The AMS plans to publish between 2 and 4 volumes in the *Contemporary Mathematics* series each year: two have been published in 2013, two in 2014, and four are planned for 2015. A new editorial board for the CRM–AMS publications was installed in 2013–2014 and consists of Luc Vinet (CRM director), Galia Dafni (CRM Deputy Director), and the following mathematicians: Jerry L. Bona (University of Illinois at Chicago), Vašek Chvátal (Concordia), Donald Dawson (Carleton), Hélène Esnault (Freie Universität Berlin), Pengfei Guan (McGill), Lisa Jeffrey (University of Toronto), Ram Murty (Queen's), Christophe Reutenauer (UQAM), Nicolai Reshetikhin (University of California, Berkeley), and Nicole Tomczak-Jaegermann (University of Alberta).

The CRM publishes "Le Bulletin du CRM" twice a year. This bulletin (of around 20 pages) includes CRM news, articles on its activities, and articles on the activities of CRM members and mathematicians honoured by the CRM.

## BOOKS PUBLISHED IN 2013 AND 2014

### CRM Monograph Series

Jean-Pierre Labesse and Jean-Loup Waldspurger, *La Formule des Traces Tordue d'après le Friday Morning Seminar*, CRMM/31, 2013.

Pavel Bleher and Karl Liechty, *Random Matrices and the Six-Vertex Model* – CRMM/32, 2014.

Liber Šnobl and Pavel Winternitz, *Classification and Identification of Lie Algebras*, CRMM/33, 2014.

Leonid Polterovich and Daniel Rosen, *Function Theory on Symplectic Manifolds*, CRMM/34, 2014.

Fritz Hörmann, *The Geometric and Arithmetic Volume of Shimura Varieties of Orthogonal Type*, CRMM/35, 2014.

### CRM Proceedings & Lecture Notes

Galia Dafni, Robert J. McCann, and Alina Stancu (eds.), *Analysis and Geometry of Metric Measure Spaces*, CRMP/56, 2013.

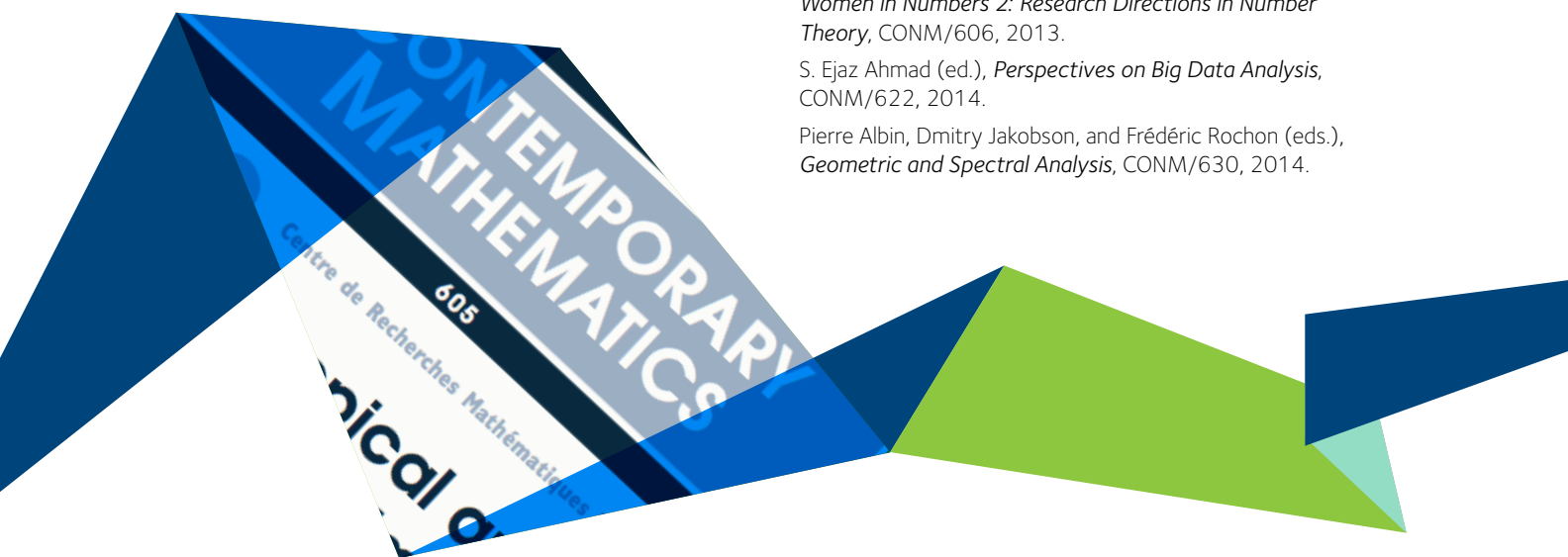
### CRM Proceedings (in Contemporary Mathematics)

Omid Amini, Matthew Baker, and Xander Faber (eds.), *Tropical and Non-Archimedean Geometry*, CONM/605, 2013.

Chantal David, Matilde Lalin, and Michelle Manes (eds.), *Women in Numbers 2: Research Directions in Number Theory*, CONM/606, 2013.

S. Ejaz Ahmad (ed.), *Perspectives on Big Data Analysis*, CONM/622, 2014.

Pierre Albin, Dmitry Jakobson, and Frédéric Rochon (eds.), *Geometric and Spectral Analysis*, CONM/630, 2014.



# GOVERNANCE AND SCIENTIFIC GUIDANCE

*THE CRM STRUCTURE CONSISTS OF A BOARD OF DIRECTORS, AN ASSEMBLY OF MEMBERS, AN INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE, A LOCAL SCIENTIFIC COMMITTEE, A MANAGEMENT COMMITTEE, AND A COMMITTEE OF DIRECTORS OF LABORATORIES. HERE ARE THE MEMBERS OF THESE COMMITTEES FOR 2013–2014 (EXCEPT FOR THE DIRECTORS OF LABORATORIES, ALREADY MENTIONED IN A PREVIOUS SECTION).*

## THE BOARD OF DIRECTORS IS COMPOSED OF:

- The Director (ex officio);
- A member of the Management Committee nominated by the Board for a two-year mandate;
- Two regular CRM members nominated by the Assembly for three-year mandates, normally renewable once;
- A Laboratory Director, nominated by the Committee of Directors of Laboratories for a two-year mandate, normally renewable once;
- The Chair of the International Scientific Advisory Committee;
- The Vice-Principal, Research, of each of the main partner universities of the CRM; and
- A Vice-Principal, Research, of one of the other partner universities of the CRM, chosen by these universities on a rotating basis for a two-year mandate.

In 2013–2014 the Board included Sophie D'Amours (Vice-Principal, Research, Université Laval), Gérard Ben Arous (Courant Institute), François Bergeron (UQAM), Graham Carr (Vice-Principal, Research, Concordia University), Christian Genest (McGill University), Jacques Hurtubise (representing the Vice-Principal, Research, McGill University), Odile Marcotte (CRM Deputy Director), Yves Mauffette (Vice-Principal, Research, UQAM), Christiane Rousseau (Université de Montréal), Geneviève Tanguay (Vice-Principal, Research, Université de Montréal), and Luc Vinet (CRM Director). Octav Cornea (Université de Montréal) and Galia Dafni (Concordia University) were invited members of the Board.

## INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE

The International Scientific Advisory Committee (ISAC) consists of outstanding Canadian or foreign researchers, who are either mathematicians or scientists with close links to the mathematical sciences. The main task of the Committee is to make recommendations on the general scientific orientations of the CRM and give advice on proposed scientific activities. In 2013–2014 the committee was chaired by Gérard Ben Arous (Courant Institute) and also included Martin Barlow (University of British Columbia), Allan Borodin (University of Toronto), Stephen E. Fienberg (Carnegie Mellon University), Edward Frenkel (University of California, Berkeley), Susan Friedlander (University of Southern California), Mark Goresky (Institute for Advanced Study), Laurent Habsieger (CNRS), Claude Le Bris (École nationale des ponts et chaussées), Dusa McDuff (Barnard College), Duong Phong (Columbia), Claus Michael Ringel (Universität Bielefeld), Keith Taylor (Dalhousie University), and Luc Vinet (Université de Montréal).

Geneviève Tanguay (Vice-Principal, Research, Université de Montréal) was an ex officio member of the ISAC. Octav Cornea, Galia Dafni, and Odile Marcotte (all three Deputy Directors of the CRM) were invited members of the ISAC.

## LOCAL SCIENTIFIC COMMITTEE

In 2013–2014 the Local Scientific Committee consisted of Vestislav Apostolov (UQAM), Christian Genest (McGill), François Lalonde (Université de Montréal), Jean-Philippe Lessard (Université Laval), Iosif Polterovich (Université de Montréal), Lea Popovic (Concordia), Luc Vinet (CRM Director), and Daniel T. Wise (McGill).

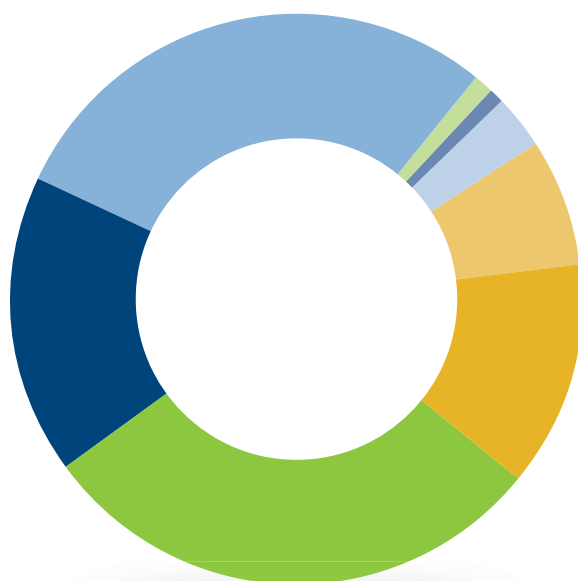
## MANAGEMENT COMMITTEE

The Management Committee of the CRM consists of: Luc Vinet (Université de Montréal, mathematical physics), director of the CRM; Galia Dafni (Concordia University, harmonic analysis), Deputy Director, Publications; Odile Marcotte (UQAM and GERAD, combinatorial optimization), Deputy Director, Partnerships; and Iosif Polterovich (Université de Montréal, geometric spectral theory), Deputy Director, Scientific Programs.



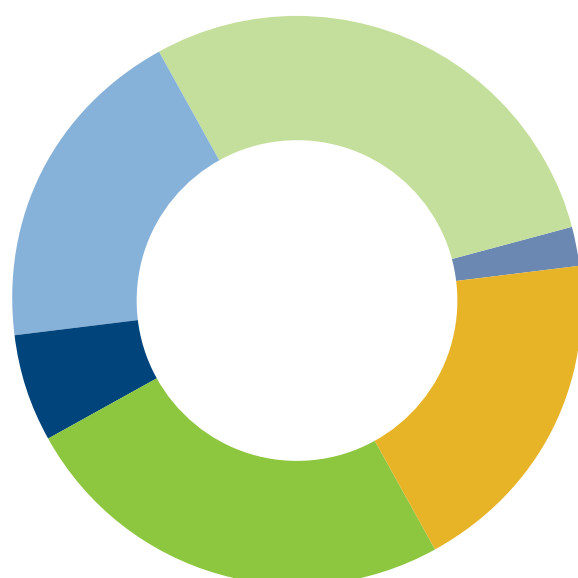
# THE CRM IN NUMBERS

## SOURCES OF FUNDING IN 2013-2014 IN THOUSANDS OF \$



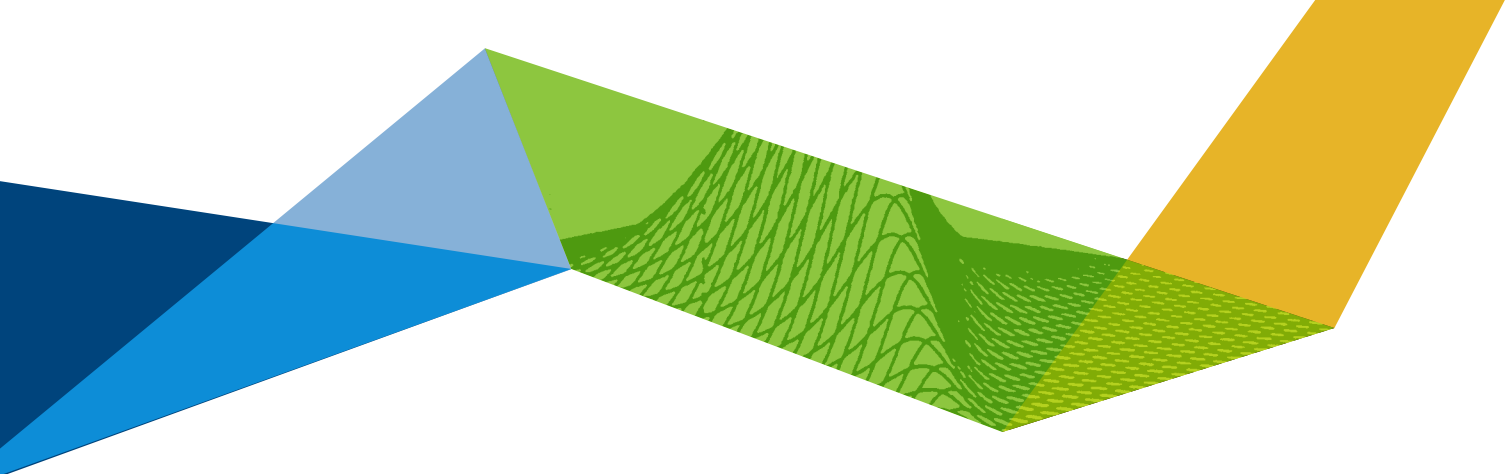
FRQNT	\$ 605
NSERC	1,345
Universities (funding)	810
Universities (in-kind)	1,340
Endowments	35
Sales and registration fees	60
Other grants	125
Partner organizations	347
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	\$ 4,667

## USE OF FUNDS IN 2013-2014 IN THOUSANDS OF \$

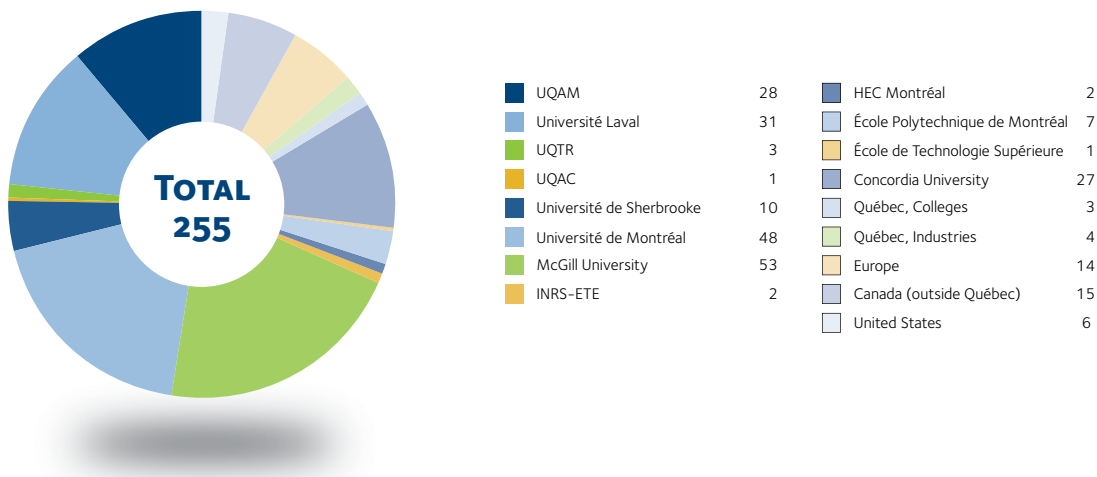


Laboratories	\$ 865
Thematic and General Programmes	1,181
Postdoctoral fellows	294
Management and staff	897
Space and services (universities)	1,340
Operating costs	90
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	\$ 4,667

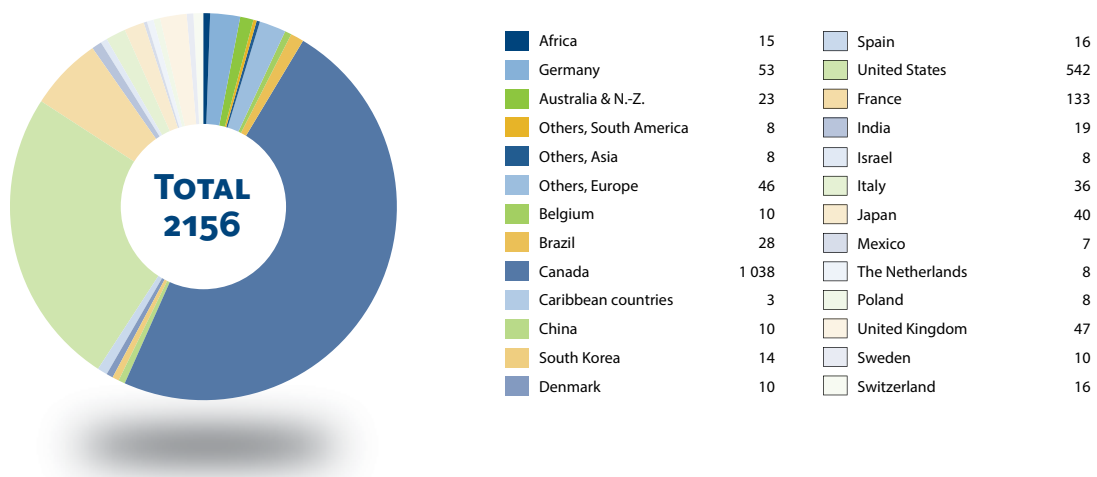




INSTITUTIONAL AFFILIATION OF CRM MEMBERS

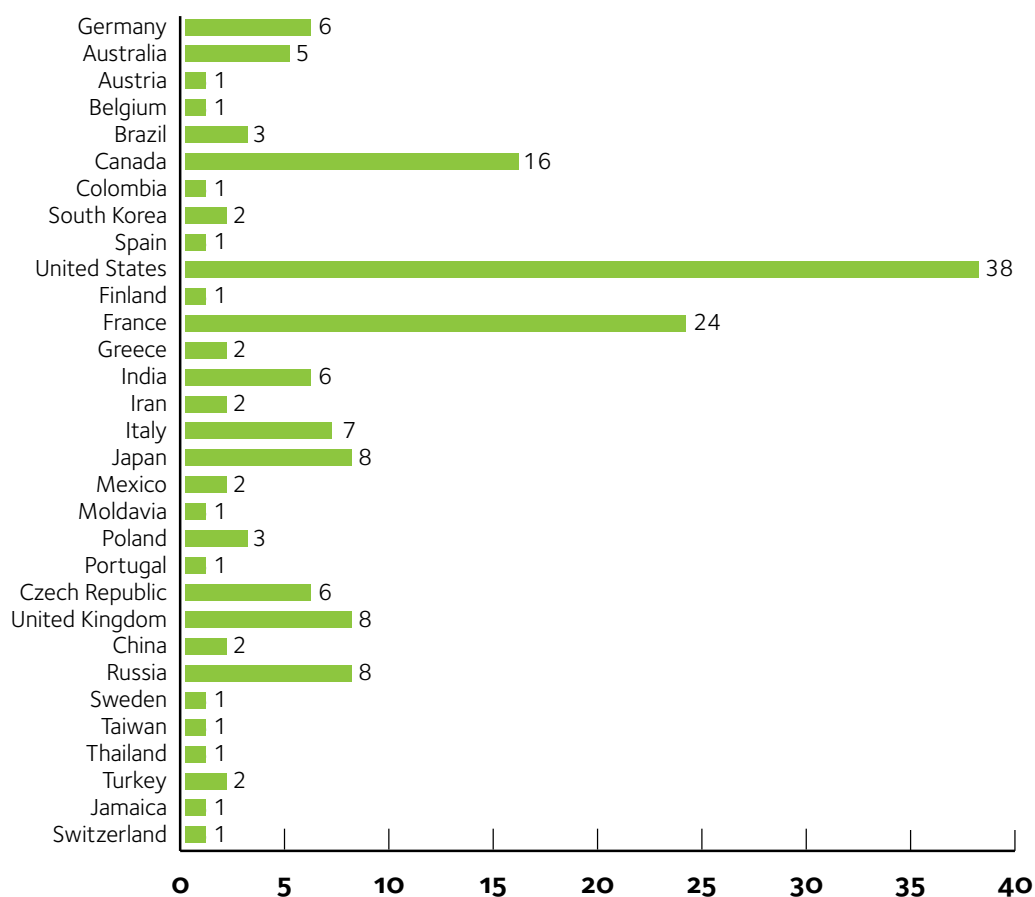


RESEARCHERS TAKING PART IN CRM ACTIVITIES, BY COUNTRY



# THE CRM IN NUMBERS (CONTINUED)

## VISITING RESEARCHERS (INCLUDING POSTDOCTORAL FELLOWS), BY COUNTRY



# CRM ADMINISTRATIVE AND SUPPORT STAFF

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## THE DIRECTOR'S OFFICE

<b>LUC VINET</b>	Université de Montréal, mathematical physics Director
<b>GALIA DAFNI</b>	Concordia University, harmonic analysis Deputy Director, Publications
<b>ODILE MARCOTTE</b>	UQAM and GERAD, combinatorial optimization Deputy Director, Partnerships
<b>IOSIF POLTEROVICH</b>	Université de Montréal, geometric spectral theory Deputy Director, Scientific Programs

## ADMINISTRATION

<b>VINCENT MASCIOTRA</b>	Head of Administration
<b>LUCIE VINCENT</b>	Secretary
<b>GUILLERMO MARTINEZ-ZALCE</b>	Research Laboratories Administrative Coordinator
<b>DIANE BRULÉ-DE FILIPPIS</b>	Administrative Assistant

## SCIENTIFIC ACTIVITIES

<b>LOUIS PELLETIER</b>	Coordinator
<b>LOUISE LETENDRE</b>	Administrative Assistant
<b>SAKINA BENHIMA</b>	Project Manager

## COMPUTER SERVICES

<b>DANIEL OUMET</b>	Systems Administrator
<b>ANDRÉ MONTPETIT</b>	Office Systems Manager (half-time)

## PUBLICATIONS

<b>ANDRÉ MONTPETIT</b>	Tex expert (half-time)
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## COMMUNICATIONS

<b>SUZETTE PARADIS</b>	Communications Officer and Webmaster
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