CENTRE DE RECHERCHES MATHÉMATIQUES

Annual Report

2012 2013

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2013

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Presenting the Annual Report 2012–2013 1

Thematic Program 3
Thematic Program of the Year 2012–2013: "Moduli Spaces, Extremality and Global Invariants" and "Mathematics of Planet Earth 2013" . . . 4
Aisenstadt Chairholders in 2012–2013: Fedor Bogomolov, David Gabai, Helmut Hofer, and Gang Tian . 5
Activities of the Thematic Year . . . 7
Past Thematic Programs . . . 18

General Program 19
CRM activities . . . 20
Colloquium and Seminar Series . . . 35

Multidisciplinary and Industrial Program 37
Activities of the Multidisciplinary and Industrial Program . . . 38

CRM Prizes 40
CRM–Fields–PIMS Prize 2013 Awarded to Bruce Reed . . . 41
André-Aisenstadt Prize 2013 Awarded to Spyros Alexakis . . . 41
The CRM–SSC Prize 2013 Awarded to Derek Bingham . . . 42

The CRM Outreach Program 44
Mathematics of Planet Earth 2013 — CRM Public Lectures . . . 45
Mathematics of Planet Earth 2013 — Cross-Canada Series of Lectures . . . 48
Grandes Conférences du CRM . . . 49

CRM Partnerships 52
CRM Partners . . . 53
Joint Initiatives . . . 56

Mathematical Education 57
Institut des sciences mathématiques (ISM) . . . 58
Other Joint Initiatives . . . 60

Research Laboratories 61
Applied Mathematics . . . 62
CICMA — Centre Interuniversitaire en Calcul Mathématique Algébrique . . . 63
CIRGET — Centre Interuniversitaire de Recherches en Géométrie et Topologie . . . 64
GIREF — Groupe Interdisciplinaire de Recherche en Éléments Finis . . . 66
LaCIM — Laboratoire de Combinatoire et d'Informatique Mathématique . . . 67
Mathematical Analysis . . . 69
Mathematical Physics . . . 71
PhysNum . . . 73
Statistics . . . 74

Publications 76
Recent Titles . . . 77
Previous Titles . . . 77

Scientific Personnel 82
CRM Members in 2012–2013 . . . 83
Postdoctoral Fellows . . . 85

Visitors . . . 86

List of Students Having Graduated in 2012–2013 **88**
Ph.D. Students . . . 89
M.Sc. Students . . . 91

Governance and Scientific Guidance **95**
Board of Directors . . . 96
Committee of Directors of Laboratories . . . 96
International Scientific Advisory Committee . . . 97

CRM Administrative and Support Staff **102**
The Director's Office . . . 103
Administration . . . 103
Scientific Activities . . . 103
Computer Services . . . 103
Publications . . . 103
Communications . . . 103

Mandate of the CRM **104**

Presenting the Annual Report 2012–2013

The 2012–2013 thematic program at the CRM was a perfect illustration of the breadth of its activities, since it included a Thematic Year on Moduli Spaces, Extremality and Global Invariants as well as the Thematic Year "Mathematics of Planet Earth 2013". Thus both pure and interdisciplinary mathematics were featured at the CRM this year. The Thematic Year on Moduli Spaces, Extremality and Global Invariants was dedicated to questions that lie at the heart of the current research in geometry. It consisted of eight research workshops (paired with mini-courses) and series of Aisenstadt lectures by Fedor Bogomolov, David Gabai, Helmut Hofer, and Gang Tian, respectively. I would like to express my thanks to the members of the Thematic Year scientific committee: Vestislav Apostolov, Steven Boyer, Virginie Charette, Olivier Collin, Octav Cornea, Jacques Hurtubise, François Lalonde, Steven Lu, Frédéric Rochon, Peter Russell, and Johannes Walcher.

The Mathematics of Planet Earth program, launched by Christiane Rousseau during her mandate as CRM director, was enthusiastically adopted by our Canadian partners and many mathematics research institutes across the globe. In particular the Mathematics of Planet Earth 2013 (MPE 2013) program was a joint initiative of Canadian institutions, with activities taking place in many locations. The goal of this thematic program was to tackle pressing and emerging challenges in population and ecosystem health, including the control of major transmissible diseases, the optimization and monitoring of vaccination, the impact of climate change on invasive species, the protection of biodiversity, and the sustainable management of ecosystems. The MPE 2013 year featured three summer schools for graduate students and postdoctoral fellows as well as workshops that took place at the CRM, the Fields Institute (in Toronto), the PIMS (in Edmonton), St. John's (under the auspices of AARMS), and BIRS. The scientific committee of the Canadian program included Jacques Bélair, Mark Lewis, Frithjof Lutscher, James Watmough, and Jianhong Wu.

The CRM is also proud of the outstanding researchers who were awarded its prizes this year: Bruce Reed from McGill University (CRM–Fields–PIMS Prize 2013), Spyros Alexakis from the University of Toronto (André-Aisenstadt Prize 2013), and Derek Bingham from Simon Fraser University (CRM–SSC Prize 2013). The public lectures that took place at the CRM in 2012–2013 were especially brilliant. Four of these were related to the MPE 2013 Thematic Year. The lectures by Ingrid Daubechies and Paul Embrechts were part of the MPE 2013 – CRM Public Lectures Series; the lecture by Professor Daubechies was actually sponsored by the prestigious Simons Foundation. The lectures by Nilima Nigam and Anthony Peirce were part of the MPE 2013 – Cross-Canada Series of Public Lectures. The fifth public lecture was given by the French physicist Alain Aspect and was part of the Grandes Conférences series.

An Unité Mixte Internationale (UMI) was established by the CNRS at the CRM in 2011 and has given an impetus to the exchanges between the CRM and the French mathematical community: sixteen French mathematicians visited the CRM and three Montréal researchers visited colleagues in France in 2012-2013 thanks to the UMI. Also in 2012-2013, the relationship between the CRM and the French mathematical community led to the organization of two colloquia within the Entretiens Jacques-Cartier (in Lyon): a colloquium on risk management and a colloquium on mathematical physics.

The activities of the CRM are supported by the Government of Canada through NSERC, the Government of Québec through FRQNT, the Government of the United States through the National Science Foundation (NSF), the Mprime network, and its partner universities: the Université de Montréal, McGill University, the Université du Québec à Montréal, Concordia University, the Université Laval, the Université de Sherbrooke, and the University of Ottawa. The Society for Mathematical Biology (SMB) provided support to students and young (particularly pre-tenure) investigators participating in the MPE 2013 program. On behalf of the CRM I extend my sincere thanks to all our partners, who help the CRM develop its activities within a world-class research program in the mathematical sciences.

Luc Vinet, Director
Centre de recherches mathématiques (CRM)

Thematic Program

Thematic Programs of the Year 2012–2013 "Moduli Spaces, Extremality and Global Invariants" and "Mathematics of Planet Earth 2013"

Moduli Spaces, Extremality and Global Invariants

Geometry in the large sense, and especially the geometry of the most natural and simple structures on manifolds, is going through a golden age. More than ever, we are close to a satisfactory understanding of the basic blocks that constitute the most intricate spaces, be they Riemannian, complex, algebraic, symplectic or dynamical. Contemplating this development, one sees the ubiquitous role played by extremality and stability understood in various contexts: the proof of the Poincaré conjecture and the parabolic methods that reach minimality in low-dimensional manifolds place us roughly at the point where mathematicians were at the end of the nineteenth century when one had to invent, beyond the analytical method of uniformization, a full topological theory needed to achieve a satisfactory classification. Minimality and extremality are also present in higher dimensions, both in the Kähler–Einstein case and in the constant scalar curvature Kähler case, where Aubin, Yau, Tian and Donaldson established basic existence theorems.

Extremality is also behind the recent spectacular proof by Taubes of the full Weinstein conjecture on the existence of closed orbits of the Reeb flow on contact manifolds. Although his proof relies on a subtle interplay between the contravariant Seiberg–Witten theory and the covariant embedded contact homology, the conjecture itself and ultimately the idea of its proof rely on the minimality of an action associated to some closed trajectory that can also be computed as a capacity. In symplectic topology and geometry, the progress over the last decade is remarkable on almost all important questions: while relative symplectic field theory, considered by some mathematicians to be the ultimate theory of classical and quantum mechanics, is developing quickly with tools coming from several parts of mathematics (analytical foundations, algebraic formalism, geometric intuition and setting), advances on all aspects of the ubiquitous Floer theory are now percolating in 3 and 4-dimensional manifolds. Almost independently, the theory of J-holomorphic curves has been used to derive real enumerative invariants, opening for the first time the field of enumerative real algebraic geometry that had, until then, stagnated since its infancy almost two centuries ago.

Moduli spaces are present everywhere: the spaces of metrics, be they Kähler or almost Kähler, the space of almost complex structures, the space of representations of the fundamental group of surfaces or 3-folds in suitable Lie groups and the so-called higher Teichmüller spaces, the Hamiltonian diffeomorphism group over which the Hofer norm is given, the space of configurations of the so-called clusters, a sort of dual to the Fukaya A-structure, the space of pseudo-algebraic functions on algebraic curves that are mysteriously connected to integrable systems, random matrices, Gromov–Witten-invariants, all of these spaces are currently attracting the attention of the mathematical community more than ever before, with an interdisciplinary perspective that is now, clearly, essential.

The theme year on "Moduli Spaces, Extremality and Global Invariants" was a hub dedicated to the study of these questions, which lie at the heart of the current developments in geometry. The program consisted of eight research workshops paired with mini-courses and several series of Aisenstadt lectures, all coordinated to maximize constructive interactions. The program also supported a number of research visitors and postdoctoral fellows so that they could work at CIRGET, the geometry-topology research laboratory of the CRM. The scientific committee of the year included the following researchers: Vestislav Apostolov (UQAM), Steven Boyer (UQAM), Virginie Charette (Sherbrooke), Olivier Collin (UQAM), Octav Cornea (Montréal), Jacques Hurtubise (McGill), François Lalonde (Montréal), Steven Lu (UQAM), Frédéric Rochon (UQAM & ANU), Peter Russell (McGill), Johannes Walcher (McGill). The organizers of the semester are very grateful to the National Science Foundation for its financial support.

Mathematics of Planet Earth 2013

As part of the Mathematics of Planet Earth 2013 (MPE 2013) initiative, a series of workshops and summer schools was organized in 2013, consisting of activities taking place across Canada. The challenges that we face on our planet are becoming increasingly complex

since ecological, economic and social systems are large intertwined networks governed by dynamic processes and feedback loops. Mathematical models are indispensable in understanding and managing such systems because they provide insight into governing processes; they help predict future behaviour; and they allow for risk-free evaluation of possible interventions. The goal of this thematic program was to tackle pressing and emerging challenges in population and ecosystem health, including the understanding and controlling of major transmissible diseases, the optimizing and monitoring of vaccination, the prediction of the impacts of climate change on invasive species, the protection of biodiversity, and the sustainable management of ecosystems.

This pan-Canadian program brought together the international community of researchers who work on these topics in a series of workshops fostering exchange and stimulating cross-disciplinary research between all scientific areas involved. Three summer schools introduced graduate students and postdoctoral fellows to the art of modelling living systems and to the latest tools and techniques for analyzing these models. These activities took place not only at the CRM in Montréal, but also at the Fields Institute in Toronto, at the PIMS in Edmonton, at St. John's under the auspices of AARMS, and at BIRS. The scientific committee of the Canadian program included Jacques Bélair (Université de Montréal), Mark Lewis (University of Alberta), Frithjof Lutscher (University of Ottawa), James Watmough (University of New Brunswick), and Jianhong Wu (York University). The National Science Foundation (NSF) and the Society for Mathematical Biology (SMB) provided funding in order to support students and young (particularly pre-tenure) investigators participating in this program.

Aisenstadt Chairholders in 2012–2013
Fedor Bogomolov, David Gabai, Helmut Hofer, and Gang Tian

Fedor Bogomolov

Professor Fedor Bogomolov is an outstanding mathematician renowned for his work in algebraic geometry and number theory. He graduated from the Faculty of Mechanics and Mathematics of the Moscow State University and earned his doctorate at the Steklov Institute in 1973. F. Bogomolov obtained his habilitation in 1983 and became a full professor at the Courant Institute in 1994. He has conducted seminal work on the geometry of Kähler manifolds, Calabi–Yau manifolds, mirror symmetry, holomorphic vector bundles, and the approach of diophantine equations through the geometry of hyperbolic manifolds and dynamical systems. We refer the reader to the Spring 2013 edition of the Bulletin du CRM for a description of Bogomolov's lectures, respectively entitled

- External and Internal Symmetries and their Role in Mathematics and Nature;
- Universal Spaces in Birational Algebraic Geometry; and
- Several Aspects of Infinite Transitivity.

David Gabai

by Steven Boyer (UQAM)

Professor David Gabai of Princeton University gave a series of four lectures during the events surrounding the workshop *The Topology of* 3*-dimensional manifolds*. Professor Gabai is a world leader in the topology and geometry of low-dimensional manifolds, with many outstanding research contributions throughout a career in which he has solved major problems and developed powerful techniques that have had a profound impact in the field. These include proofs of the Seifert fiber space conjecture (1992), the rigidity of homotopy hyperbolic 3-manifolds (1994), the Smale Conjecture for hyperbolic 3-manifolds (2001), and Marden's Tameness Conjecture (2006). He was awarded the Oswald Veblen Prize in Geometry by the American Mathematical Society in 2004, and was made a member of the American National Academy of Sciences in 2012.

Professor Gabai's first two lectures were expository in nature. The first provided an overview of Poincaré's many contributions to topology, remarkable for their foundational and seminal nature as well as their impact on subsequent research. The second surveyed the still mysterious field of the volumes of hyperbolic 3-manifolds from W. Thurston's 1970s proof that the set of such positive real numbers is closed and well ordered, to Professor Gabai's 2009 theorem with Robert Meyerhoff and Nathaniel Thurston that the Weeks

manifold is the unique manifold to realize the minimal possible volume among closed orientable hyperbolic 3-manifolds. He described the three decades of effort by many mathematicians, using a wide variety of techniques, that bridged these results, including the use of Ricci flow by Ian Agol and Nathan Dunfield to obtain strong volume estimates. The talk concluded with a discussion of open problems and an approach for addressing the Thurston, Weeks, Matveev–Fomenko conjecture that complete low-volume hyperbolic 3-manifolds are of low topological complexity.

Professor Gabai's last two Aisenstadt Chair lectures focused on the topology of the ending lamination space associated to a finite type hyperbolic surface S. He set the stage by describing its connections with the space of projective measured laminations of S, the Gromov boundary of the curve complex of S, and the set of doubly degenerate hyperbolic structures on $S \times \mathbb{R}$. Most of his time was devoted, though, to explaining his recent results in the area. For instance, if S has genus g and p punctures, then its ending lamination space is both $(n-1)$-connected and $(n-1)$-locally-connected where $2n+1 = 6g+2p-7$. Further, when g is zero, its ending lamination space is the Nöbeling space of points in $\mathbb{R}^{2m+1}$ with at most m rational coordinates.

Helmut Hofer

by Octav Cornea (Université de Montréal)

Helmut Hofer obtained his Ph.D. at the University of Zürich in 1981 and is currently a permanent member of the Institute for Advanced Study in Princeton. Among other prestigious distinctions, he is a member of the National Academy of Sciences and was twice an invited speaker at an International Congress of Mathematicians (the second time, in 1998, he was actually a plenary speaker). Hofer is one of the founders of modern symplectic topology. His work, alone and with collaborators, on Floer theory, on capacities and applications to Hamiltonian dynamics, and on cases of the Weinstein conjecture in dimension three was transformational. It led to the establishment and the further study by countless researchers of (what is now called) the Hofer geometry of the Hamiltonian diffeomorphisms groups. More recently, together with Wysocki and Zehnder he is developing polyfold theory, a wide-reaching extension of usual differential geometry particularly adapted to the study of regularity properties of moduli spaces of solutions of PDEs.

The topic of Hofer's talks was *Hamiltonian Dynamics and Symplectic Rigidity*. Hamiltonian systems, which occur frequently in physics, are also of great interest in many branches of mathematics. Symplectic geometry allows us to formulate certain dynamical questions into geometric and, sometimes, even algebraic problems. This is based on the properties of the moduli spaces of (perturbed) J-holomorphic curves that naturally arise in relation to a given Hamiltonian system, once the appropriate action functional is defined. Assuming that these moduli spaces are well-behaved, they are amenable to combinatorial assembly and the output is presented as certain homological type invariants such as Gromov–Witten invariants, Floer homology, and others. Understanding of these invariants sheds light on the dynamical properties of the initial Hamiltonian system. In the last twenty years the symplectic machinery that follows this general scheme has developed tremendously. Hofer's talks reviewed part of these developments, and emphasized that the time has come for a renewed exploration of questions originating in celestial mechanics and space transportation by using all the sophisticated tools at our disposal today.

Gang Tian

by Vestislav Apostolov (UQAM)

Professor Gang Tian, who is Eugene Higgins Professor at Princeton and the director of the Beijing International Centre for Mathematical Research (BICMR), gave a series of three Aisenstadt lectures during the workshop *Extremal Kähler metrics*. In global analysis and geometry over the last 25 years, Professor Gang Tian has been one of the most influential and versatile figures. From his Ph.D. thesis to his most recent work, his contributions have been distinguished by their diversity and depth. His most striking work to date concerns the existence of Kähler–Einstein metrics on complex manifolds (which was a main theme of the workshop), but he has made many other significant contributions. For instance, he established (with Y. Ruan) the associativity of the quantum cohomology ring of a symplectic manifold, constructed (with Jun Li) moduli spaces of curves in algebraic symplectic geometry, elaborated (with J. Morgan) a clear and detailed exposition of Perelman's proof of the Poincaré conjecture, and developed ideas to link Kähler–Ricci flow with the Mori program in algebraic geometry.

Most relevant to this CRM workshop, however, is Tian's work on Kähler–Einstein metrics. In his early career, he solved the existence question for Kähler–Einstein metrics on compact complex surfaces with positive first Chern class, and showed that Fano varieties with a Kähler–Einstein metric must be stable in the sense of geometric invariant theory, thus confirming part of a suggested correspondence by Yau. Professor Tian gave a precise formulation of this correspondence, known today as the Yau–Tian–Donaldson conjecture, identifying the obstruction to the existence of Kähler–Einstein metrics with what is now called the K-stability of the Fano variety. His ideas have inspired a tremendous amount of work in recent years, and spectacular progress has been made, culminating in the complete resolution of the conjecture by Tian himself, and by Xiuxiong Chen, Simon Donaldson and Song Sun.

Professor Tian's first lecture was expository in nature, and reviewed the theory and latest progress related to the existence of Kähler–Einstein metrics. The second lecture was concerned with a more detailed exposition of the key ideas of Professor's Tian most recent work regarding the existence of Kähler–Einstein metrics on a K-stable Fano variety. The third lecture featured recent results on convergence of the Kähler–Ricci flow on a Fano variety.

Aisenstadt Chair

The Aisenstadt chair was endowed by Montréal philanthropist Dr. André Aisenstadt. Under its auspices, one or more distinguished mathematicians are invited each year for a period of at least one week, ideally one or two months. During their stay the lecturers present a series of lectures on a specialized topic. They are also invited to prepare a monograph (see the chapter on publications in the present report for a list of these monographs). At the request of Dr. Aisenstadt, the first lecture given by an Aisenstadt chairholder should be accessible to a wide audience. Previous holders of the Aisenstadt chair are: Marc Kac, Eduardo Zarantonello, 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, Sir 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, Yuri Gurevich, Angus Macintyre, Alexander Razborov, James Robins, John Preskill, Renato Renner, László Erdős, Elon Lindenstrauss, Richard M. Schoen.

Activities of the Thematic Year

The reports are presented in the language in which they were submitted. As far as MPE 2013 is concerned, we have given the list of all the activities taking place in Canada but included reports only for the CRM activities.

Workshop
Spectral Invariants on Non-Compact and Singular Spaces

July 23–27, 2012, CRM
Sponsored by the CRM, the NSF, and the Australian National University

Organizers:
Pierre Albin (UI Urbana-Champaign), Frédéric Rochon (UQAM & ANU)

Speakers:
Spyros Alexakis (Toronto), Dean Baskin (Northwestern), Jean-Michel Bismut (Paris-Sud), David Borthwick (Emory), Maxim Braverman (Northeastern), Jochen Brüning (Humboldt), Tanya Christiansen (Missouri), Xianzhe Dai (UC Santa Barbara), Kiril Datchev (MIT), Daniel Grieser (Oldenburg), Colin Guillarmou (ÉNS), Chris Kottke (Brown), Zhiqin Lu (UC Irvine), Xiaonan Ma (Paris Diderot), Jeremy Marzuola (UNC—Chapel Hill), Richard Melrose (MIT), Gerardo Mendoza

(Temple), Jinsung Park (KIAS), Bert-Wolfgang Schulze (Potsdam), Michael Singer (Univ. Coll. London), Gunther Uhlmann (Washington), Mathai Varghese (Adelaide), András Vasy (Stanford), Siye Wu (Hong Kong), Jared Wunsch (Northwestern), Ken-Ichi Yoshikawa (Kyoto), Steve Zelditch (Northwestern)

Number of participants: 44

Le premier atelier de l'année thématique a eu lieu au CRM du 23 au 27 juillet, 2012. Les organisateurs étaient Pierre Albin (Urbana-Champaign) et Frédéric Rochon (UQAM). Il y avait entre 5 et 6 exposés par jour, pour un total de 25 exposés. Les exposés étaient de 50 minutes, ce qui a donné suffisamment de temps à chaque conférencier pour présenter ses résultats, donner une idée des méthodes utilisées et mentionner des questions ouvertes. Même si l'horaire était assez rempli, les participants ont aussi eu plusieurs occasions d'échanger, notamment durant les pauses-café et sur l'heure du lunch.

Un mélange intéressant de sujets a été abordé. Certains exposés portaient sur la théorie de l'indice (ceux de Wu, Varghese, Brüning et Kottke) ou sur des invariants spectraux apparentés tels l'invariant êta et la torsion analytique (Melrose, Park, Ma, Yoshikawa et Dai). D'autres portaient plutôt sur la théorie de la diffusion, notamment les exposés de Christiansen, Bortwick, Baskin, Vasy, Datchev, Guillarmou, ou plus généralement sur l'analyse spectrale, comme dans les exposés de Lu, Marzuola, Wunsch et Grieser. Certains résultats touchant à la géométrie complexe ont été abordés dans les exposés de Mendoza et Singer. Enfin, certains sujets étaient plus spécialisés, comme l'exposé de Jean-Michel Bismut sur le Laplacien hypoelliptique ou l'exposé de Spyros Alexakis utilisant l'analyse non linéaire. Plusieurs conférenciers ont accepté de partager leurs transparents et ces derniers sont disponibles sur la page web de l'atelier.

Un des beaux moments de l'atelier est sans doute l'exposé de Jared Wunsch, qui a expliqué avec une grande clarté son résultat le plus récent obtenu avec Dean Baskin. D'ailleurs, en collaboration avec un autre participant de l'atelier, Jeremy Marzuola, ils ont l'intention d'écrire un article utilisant leur résultat pour obtenir une estimation de Strichartz globale sur des domaines extérieurs à des polygones.

En collaboration avec un autre atelier du CRM, celui de juin 2012 portant sur la géométrie des valeurs propres et fonctions propres, nous projetons de publier des actes de conférence. Plusieurs participants se sont déjà montrés intéressés à apporter leur contribution, ce qui devrait mener à un ouvrage intéressant.

Mini-course & Workshop
The Topology of Algebraic Varieties

September 21–28, 2012, CRM
Sponsored by the CRM and the NSF

Organizers:
Rajendra Gurjar (Tata Inst.), Shulim Kaliman (Miami), Steven Lu (UQAM), Peter Russell (McGill)

Lecturers:
Ryoichi Kobayashi (Nagoya), Adrian Langer (Warsaw), Terrence Napier (Lehigh), Walter Neumann (Columbia), Anne Pichon (Aix-Marseille), Mohan Ramachandran (Buffalo)

Speakers:
Shreeram Abhyankar (Purdue), Donu Arapura (Purdue), Fedor Bogomolov (Courant Inst.), Frédéric Bruno Campana (Henri Poincaré), Fabrizio Catanese (Bayreuth), Bruno de Oliveira (Miami), Philippe Eyssidieux (Joseph Fourier), Hubert Flenner (Bochum), Ludmil Katzarkov (Miami), JongHae Keum (KIAS), Ryoichi Kobayashi (Nagoya), Mariusz Koras (Warsaw), Frank Kutzschebauch (Bern), Adrian Langer, Michael McQuillan (IHÉS), Masayoshi Miyanishi (Kwansei Gakuin), Terrence Napier, Madhav Nori (Chicago), Bangere Purnaprajna (Kansas), Mohan Ramachandran, Sheng-Li Tan (East China NU), Jörg Winkelmann (Bochum)

Number of participants: 68

Friday September 21 and the following weekend were occupied by three mini-courses of four lectures each. The first mini-course, on topological methods in the study of singularities (by Anne Pichon and Walter Neumann) was perhaps the most accessible for the audience, which included many postdoctoral fellows and graduate students. Starting with classical results on the topology of isolated singularities (Milnor fibration, iterated torus links, Puiseux expansions), the speakers introduced the concept of metrically convex singularity, the new Thick–Thin decomposition, Carousel structure, and applications to Lipschitz geometry of isolated singularities. The lecturers (Terrence Napier and Mohan Ramachandran) of the second mini-course discussed the geometry of noncompact Kähler manifolds and the structure theorem for these objects (in particular they described conditions under which such a manifold admits a proper holomorphic map onto a Riemann surface). In the third mini-

course, Adrian Langer concentrated on the generalization of the Bogomolov–Miyaoka–Yau inequality to singular quasiprojective varieties, while R. Kobayashi discussed the modern approach to Nevanlinna theory that he introduced and that was motivated by the BMY inequality.

The workshop lectures started on Monday, September 24. Among these there were several strong reports including solutions of old problems. We mention a few: M. Koras presented an idea of a solution of the Coolidge–Nagata conjecture stating that any plane rational curve with locally irreducible singularities can be rectified by birational automorphisms of the plane; F. Kutzschebauch gave a sketch of the solution of the Gromov–Vaserstein problem (via Gromov's h-principle); J. Keum lectured on the algebraic version of the Montgomery–Yang problem (as suggested by J. Kollar); in L. Katzarkov's lecture, phantoms of derived categories were used as a new invariant that allows to show nonrationality of a variety even in the case when the intermediate Jacobian does not work; F. Canatese explained new results on moduli space of curves whose automorphism groups contain a given finite group; H. Flenner, reporting on joint work with S. Kaliman and M. Zaidenberg, presented a definitive result on deformations of affine surfaces with an $\mathbf{A}^1$-fibration; B. Purnaprajna reported on joint work with R. Gurjar on the fundamental groups of surfaces with finite automorphism groups, which leads to a solution of the Shafarevich conjecture for certain interesting classes of surfaces; F. Campana explained his joint work with J. Winkelmann on an attempt to relate special varieties to varieties that satisfy the h-principle, the so-called Oka varieties; M. McQuillan explained his solution of Lang's conjecture concerning holomorphic curves in surfaces of general type (which improved upon the Chern inequality bound of Bogomolov).

In a lecture liberally annotated with historical reminiscences, S. S. Abhyankar reported on new results on local fundamental groups and Galois theory, results that have their origin in his papers on this subject in the American Journal of Mathematics in 1955 and 1956. His talk, in retrospect, had a special poignancy since sadly Professor Abhyankar passed away not long after the conference.

Workshop
Higher Teichmüller–Thurston Theory

October 15–19, 2012, CRM
Sponsored by the CRM and the GEAR Network

Organizers:
Virginie Charette (Sherbrooke), William M. Goldman (Maryland), François Labourie (Paris-Sud), Anna Wienhard (Princeton)

Speakers:
Thierry Barbot (Avignon), Ara Basmajian (Graduate Ctr., CUNY & Hunter Coll., CUNY), Martin Bridgeman (Boston Coll.), Suhyoung Choi (KAIST), Jeffrey Danciger (UT Austin), Todd A. Drumm (Howard), Viveka Erlandsson (Graduate Ctr., CUNY), William M. Goldman, François Guéritaud (Lille 1), Tobias Hartnick (Technion), Fanny Kassel (CNRS Lille 1), Steven Kerckhoff (Stanford), Youngju Kim (KIAS), Evelyn Lamb, Sean Lawton (Texas-Pan American), Brice Loustau (Paris-Sud), Sara Maloni (Paris-Sud), Karin Melnick (Maryland), Clara Rossi Salvemini (Avignon), Ser Peow Tan (NU Singapore), Michael Wolf (Rice)

Number of participants: 34

La théorie supérieure de Teichmüller-Thurston traite notamment d'espaces de déformations de structures géométriques localement homogènes, de représentations de groupes fondamentaux de surfaces, et de connections plates. L'atelier s'est concentré sur les aspects liés aux métriques lorentziennes conformément plates, les structures géométriques issues de représentations d'Anosov, ainsi que la géométrie des composantes de Hitchin, laquelle généralise celle de Weil-Petersson sur l'espace de Teichmüller.

Des présentations ont notamment porté sur la métrique de pression sur les représentations de Hitchin, les variétés modelées sur l'espace anti-De Sitter, ainsi que les variétés lorentziennes plates. Nous avons aussi pu profiter de présentations portant sur des sujets plus proches de la théorie de Teichmüller classique, tels que les représentations quasi fuchsiennes, ainsi que la géométrie lorentzienne.

Il y avait une trentaine de participants, en provenance de plusieurs pays: Canada, États-Unis, France, Corée et Singapour. Soulignons que plusieurs jeunes chercheurs, chercheurs postdoctoraux et étudiants gradués, ont eu l'occasion de présenter leurs résultats pendant l'atelier. Nous avons privilégié une formule où il y avait relativement peu de présentations (au plus six

par jour), afin que les gens aient le temps de parler de leurs travaux et d'échanger informellement.

Nous pouvons dire que l'atelier a été un franc succès. Nous avons reçu plusieurs courriels de remerciements et de félicitations pour l'atelier. Les gens ont apprécié la taille de l'atelier: comme nous n'étions que trente participants dans des domaines adjacents, nous pouvions échanger aisément entre nous. C'est pour cette raison que l'atelier a sans doute favorisé l'émergence de nouvelles collaborations.

Workshop
Disease Dynamics 2013: Immunization, a true multi-scale problem

January 17–19, 2013, PIMS
Sponsored by PIMS, Mitacs, and Mathematics of Planet Earth 2013

Organizers:
Jessica Conway (Los Alamos Natl. Lab.), Dan Coombs (UBC), Rafael Meza (Michigan)
Speakers:
Rustom Antia (Emory), Dennis Chao (Fred Hutchison Cancer Res. Ctr.), Miles Davenport (New South Wales), Elamin Elbasha (Merck Res. Labs.), Jane Heffernan (York), Katia Koelle (Duke), Jan Medlock (Clemson), David Patrick (UBC), Alan Perelson (Los Alamos Natl. Lab.), Timothy Reluga (Penn State), Jamie K. Scott (Simon Fraser), David P. Wilson (New South Wales)

Workshop
Models and Methods in Ecology and Epidemiology

February 13–15, 2013, CRM
Sponsored by the CRM and the Society of Mathematical Biology

Organizers:
Jacques Bélair (Montréal), Jianhong Wu (York)
Speakers:
Madhur Anand (Guelph), Tamara Awerbuch (Harvard), Christopher Bauch (Guelph), Lydia Bourouiba (MIT), David L. Buckeridge (McGill), David A. Campbell (Simon Fraser), Frédéric Guichard (McGill), Johan A. P. Heesterbeek (Utrecht), Patrick Leighton (Montréal), Subhash R. Lele (Alberta), Rongsong Liu (Wyoming), Bernard Moulin (Laval), Calistus Ngonghala (Tennessee), Nicholas Hume Ogden (Montréal), John Takekawa (U.S. Geological Survey), Jianhong Wu (York), Huaiping Zhu (York)

Number of participants: 31

In epidemiology and ecology, models are typically developed along one of two directions: directly from available data, incorporating as many empirical records as possible, or conceptually as dynamical systems, incorporating data via estimation of parameters. The means of investigation for these model classes are quite distinct, and an important methodological problem is the reconciliation of a priori method-independent issues when they are described in different terms.

The two main objectives of this workshop were to

- start the interactions for the Thematic Year, by breaking community/network barriers between the practitioners of different modelling techniques and approaches, and
- follow up on activities held at the CRM on related topics in the recent past (on Statistical Methods, in March 2007 and March 2010, respectively).

A non-exclusive emphasis has been put on zoonotic diseases, given the concentrated expertise at the Université de Montréal, through the Faculté de Médecine Vétérinaire, and the significance and novelty of the problems they entail.

The sessions of this three-day workshop corresponded to the different technical approaches in modelling: dynamical systems with parameter estimation including variability; empirical models (some based on geographical information systems) of zoonotic diseases; and methodological issues in surveillance and data incorporation in epidemiological models.

Workshop
Establishing the scientific foundation for Quantitative Public Health Decision-Making

April 29–30, 2013, Fields Institute for Research in Mathematical Sciences
Sponsored by the Fields Institute for Research in Mathematical Sciences, Mprime, and Mathematics of Planet Earth 2013

Organizers:
David Buckeridge (McGill), Charmaine Dean (Western Ontario) Jianhong Wu (York)
Speakers:
Amy Greer (PHAC), Sarah Henderson (BCCDC), Fran Jamieson (PHO), Hedy Jiang (Toronto), Andre Kushniruk (Victoria), Seyed Moghadas (York), Trisalyn Nel-

son (Victoria), Beate Sander (PHO), Cécile Tremblay (INSPQ)
Number of participants: 42

Workshop
J-Holomorphic Curves in Symplectic Geometry, Topology and Dynamics
April 29–May 10, 2013, CRM

Organizers:
Denis Auroux (UC Berkeley), Octav Cornea (Montréal), Yael Karshon (Toronto), François Lalonde (Montréal), Leonid Polterovich (Tel Aviv)
Speakers:
Mohammed Abouzaid (Columbia), Paul Biran (ETH Zürich), Strom Borman (Chicago), Lev Buhovsky (Tel Aviv), Olguta Buse (IUPUI), Tobias Ekholm (Uppsala), Yakov Eliashberg (Stanford), Michael Entov (Technion), Urs Frauenfelder (Seoul NU), Kenji Fukaya (Kyoto), Sheel Ganatra (Stanford), Basak Gürel (Vanderbilt), Richard Hind (Notre Dame), Ko Honda (Southern California), Michael Hutchings (UC Berkeley), Michael Khanevsky (Chicago), Siu-Cheong Lau (Harvard), Robert Lipshitz (Columbia), Chiu-Chu Liu (Columbia), Dusa McDuff (Columbia), David Nadler (UC Berkeley), Alexandru Oancea (UPMC), Tim Perutz (UT Austin), Sheila Sandon (Nantes), Felix Schlenk (Neuchâtel), Paul Seidel (MIT), Nicholas Sheridan (IAS), Jake Solomon (Hebrew), Susan Tolman (UI Urbana-Champaign), Michael Usher (Georgia), Katrin Wehrheim (MIT), Jean-Yves Welschinger (Lyon 1), Christopher Woodward (Rutgers)
Number of participants: 98
This workshop consisted of 38 one-hour lectures, including three series of three one-hour lectures (one of which was the Aisenstadt Chair series delivered by Helmut Hofer). The other two minicourses were given by Abouzaid and Sandon, respectively. There are three different aspects of this workshop that made it a very successful and productive meeting:

1. High quality talks on the hottest topics in the subject:
- Breakthroughs in classical problems were described in talks of Buse and Hind (who proved a remarkable form of packing stability), Seidel who described a new approach to multiple Lagrangian nonintersections, Welshinger who explained his approach to estimating Betti numbers of algebraic varieties, and Eliashberg who explained recent advances in symplectic flexibility;
- Mirror symmetry, possibly the most "explosive" topic relating symplectic topology to mathematical physics, was discussed by Ganatra, Sheridan, Perutz, Lau and Nadler. In particular, Sheridan explained his proof of the HMS conjecture in a number of cases;
- Advances in symplectic dynamics appeared in the presentations of Entov, Khanevsky and Buhovsky;
- Hamiltonian dynamics applications were covered by talks of Usher, Schlenk, Gürel;
- New perspectives on Lagrangian topology were reflected in talks of Biran, Woodward, Borman, Solomon, Ekholm;
- Legendrian topology topics were discussed in talks of Hutchings and Honda. In particular, Hutchings' talk on applications of his Embedded Contact Homology described some of the most fruitful recent developments in the study of Reeb dynamics;
- Foundational issues that come into focus today appeared in the presentations of McDuff, Fukaya, and Frauenfelder;
- Finally, the talks of Oancea, Tolman, and Liu touched on other topics of high interest today, among them string topology and enumerative invariants.

2. Three insightful lecture series: The talks mentioned above were complemented by lecture series, particularly accessible to graduate students and young researchers.
- Hofer talked about potential applications of today's most refined symplectic techniques to celestial mechanics. The origins of symplectic topology lie in problems that emerged from celestial mechanics, in particular the n-body problem. Hofer's perspective was that time has come for the modern tools of symplectic topology to be applied again effectively to the mechanics of the solar system and, in particular, space travel;
- Abouzaid discussed the delicate details of coherent orientations in relation to the interplay between string topology and symplectic homology of cotangent bundles;
- Sandon explained the discrete metrics on contactomorphism groups that she recently introduced as well as related techniques and conjectures.

3. A high number of young brilliant researchers: It became clear, in part as a result of this conference, that symplectic topology is at a very special moment in its development. Suddenly, a new generation is

entering the field with great energy and brilliance. Sheridan, Borman, Ganatra, Abouzaid, Sandon, Perutz, Buhovsky, Khanevsky, Usher, Frauenfelder, Solomon, Oancea are all young and extremely promising researchers who spoke at this conference. Some of them have already made an important mark on the field and most of the others will do so in the not too distant future. A great contribution to the success of the meeting was also made by the other participants so that, as a whole, most of the top world researchers in the subject participated in this event in one form or another.

Workshop
Major and Neglected Diseases in Africa

May 6–10, 2013, Ottawa
Sponsored by the CRM and the Society of Mathematical Biology

Organizers:
Julien Arino (Manitoba), Jane Heffernan (York)
Speakers:
Cameron Browne (Ottawa), David Buckeridge (McGill), Abba Gumel (Manitoba), Jane Heffernan, Senelani Dorothy Hove-Musekwa (NUST Zimbabwe), Michael Li (Alberta), Connell McCluskey (Wilfrid Laurier), Elaine Nsoesie (Harvard), Kathleen O'Reilly (Imperial Coll.), Nitika Pai (McGill), Gauthier Sallet (INRIA Nancy), Kevin Schwartzman (McGill), Robert Smith (Ottawa), Donald Sutherland (CSIH), Kate Zinszer (McGill), Pascal Zongo (Antilles et Guyane)
Number of participants: 30

The workshop on Major and Neglected Diseases in Africa was sponsored by the CRM as part of the Mathematics of Planet Earth (MPE) thematic year. The workshop organizers, Jane Heffernan and Julien Arino, are also members of the Centre for Disease Modelling, a group based at York University. The rationale for the workshop stemmed from the observation that there are serious public health implications of the fact that while Africa counts 54 countries and 15 percent of the world population, the combined GDP of African countries represented in 2003 just over 3 percent of the world's GDP. From a demographic perspective, Africa is characterized by an overrepresentation of youth (40 percent of its population is under 15), and a life expectancy that is below 65 years (e.g., 31.6 years in Botswana), compared to 82.6 years in Japan. Several factors contribute to this low life expectancy (e.g., poverty, inadequate health care systems), but the main reason is the compounding of these factors with the effect of several major infectious diseases and some less known ones that are plaguing the continent.

Mathematical models are increasingly accepted in the public health domain as tools to fight infectious diseases. Modelling is helpful mostly because it allows for simple hypothesis testing where most other tests are impossible. Modelling is also a valuable tool that allows to pinpoint gaps in data collection. The workshop focused on some major killers (HIV/AIDS, malaria, and tuberculosis) and also considered some diseases that are, for one reason or another, less in the spotlight: childhood diseases, other viral/bacterial/vector diseases, poliomyelitis. The objectives of the workshop were the following:

- To combine the expertise of public health officials and researchers in biology and mathematical sciences in the areas of infectious diseases relevant to Africa;
- To encourage and seek participation of African colleagues, to foster collaborations between Canadian and African researchers;
- To compare experiences in dealing with public health authorities, helping all participants develop a better understanding of this difficult yet crucial aspect;
- To train junior researchers, postdoctoral fellows and graduate students.

Each day of this five-day workshop was devoted to a particular disease or group of diseases, with a few presentations on the disease(s) of interest followed by a group discussion on the subject. There were a total of 18 presentations. Monday had talks about Poliomyelitis (morning) and Schistosomiasis and other neglected tropical diseases (afternoon). Each of the next three days was devoted to one of the "Big Three" infectious diseases, i.e., the diseases associated with the highest mortality rates in Africa: HIV/AIDS was discussed on Tuesday, Malaria on Wednesday, and Tuberculosis on Thursday. Finally, on Friday morning, the focus shifted to the problem of surveillance. Each day featured four plenary talks and two discussion sessions. Each disease topic included a talk from the public health perspective and a mathematical modelling talk. Each public health talk reviewed past and current issues related to the infectious disease epidemiology, with certain African regions being highlighted. The mathematical modelling talks provided an overview of the current modelling literature centered on the infectious disease in question, and introduced some new models having

the potential to address current issues in epidemiology. In the discussion sessions, participants identified gaps in our knowledge and discussed the role of mathematical modelling in the particular thematic areas. A group of researchers from the workshop have continued discussions and are currently working on a study of community-based care and self-testing in HIV affected communities.

There were 30 registered participants to the workshop, hailing from several countries: 1) Canada (19); 2) France (2); 3) French Guyana (1); 4) Ghana (3); 5) United Kindgom (1); 6) USA (2); 7) Zimbabwe (2). The presence of participants from African institutions as well as members of the African diaspora working in North America and Europe helped the workshop "stay on focus," since many of the attendees had first-hand experience of the diseases being discussed. The workshop was attended by participants with public health and mathematical backgrounds, and participants at diverse career stages: from master's students to senior researchers and public health officials.

Workshop
The Topology of 3-Dimensional Manifolds

May 6–17, 2013, CRM

Organizers:
Michel Boileau (Paul Sabatier), Steven Boyer (UQAM), Marc Lackenby (Oxford), Alan Reid (UT Austin)

Lecturers:
Ian Agol (UC Berkeley). Tao Li (Boston Coll.), Juan Souto (UBC)

Speakers:
Ian Biringer (Boston Coll.), Jeffrey F. Brock (Brown), Ken Bromberg (Utah), Nathan M. Dunfield (UI Urbana-Champaign), Stefan Friedl (Köln), Paolo Ghiggini (CNRS & Nantes), Joshua Evan Greene (Boston Coll.), Jesse Johnson (Oklahoma State), Alexander Kolpakov (Vanderbilt), Christopher J. Leininger (UI Urbana-Champaign), Yi Liu (Caltech), Darren Long (UC Santa Barbara), Jessica Purcell (Brigham Young), Saul Schleimer (Warwick), Genevieve Walsh (Tufts), Daniel T. Wise (McGill), Zhongtao Wu (Caltech)

Number of participants: 82

The events surrounding the workshop "The topology of 3-dimensional manifolds" were held over two weeks, from May 6 to May 17, 2013. The first week was devoted to students and other young mathematicians. Three mini-courses were given by Ian Agol, Tao Li, and Juan Souto, respectively, and David Gabai delivered the first two of his four Aisenstadt Chair lectures. The second week saw the completion of Gabai's lectures as well as a workshop focusing on recent advances and future research directions in the topology of 3-dimensional manifolds. Over eighty participants from North America, Europe and Asia were attracted to the events.

Week 1 began with Juan Souto's mini-course "Eigenvalues of the Laplacian and the topology of hyperbolic 3-manifolds," which detailed how soft geometric methods could be used to estimate such eigenvalues. The theory was illustrated with examples from 3-dimensional geometry leading to a proof that if M is a closed hyperbolic 3-manifold, then the first nonzero eigenvalue of its Laplacian is bounded from above by the ratio of a constant depending on the Heegaard genus of M and its volume. The second mini-course, presented by Ian Agol, focused on the fundamental groups of 3-manifolds, a field which has seen major advances over the last decade. The first two lectures dealt with consequences of Perelman's geometrization theorem and the tameness theorem of Agol and Calegari-Gabai. The last two lectures outlined the deep work of Dani Wise on special cube complexes as well as Agol's contributions in this area leading to his recent proofs of the virtual Haken conjecture, Thurston's virtual fibring conjecture, and the subgroup separability of Kleinian groups. Tao Li's mini-course dealt with the modern theory of Heegaard splittings. After discussing basic examples and properties, strongly irreducible Heegaard splittings were introduced, leading to a proof of the generalized Waldhausen conjecture through the use of essential laminations. Other topics discussed were applications of the curve complex to Heegaard splittings and an outline of a construction of a 3-manifold whose fundamental group has rank strictly smaller than its Heegaard genus. Each mini-course ended with a list of open problems and future directions.

David Gabai gave two of his four Aisenstadt Chair lectures at the end of week 1, both of an expository nature. The subject of the first was Poincaré's contributions to topology, remarkable for their foundational and seminal nature as well as their impact on subsequent research. The second lecture surveyed the beautiful and mysterious field of the volumes of hyperbolic 3-manifolds and discussed Gabai's ongoing work with Meyerhoff and (Nathaniel) Thurston in the area. His last two Aisenstadt Chair lectures were incorporated

into the workshop held during week 2. They focused on the topology of the ending lamination space associated with a hyperbolic surface. These spaces, important in both hyperbolic geometry and geometric group theory, are the focus of much current research with many basic questions remaining open. Gabai outlined his recent progress towards characterizing their topology.

Fifteen one-hour-long talks of exceptional quality representing the state of the art in a number of areas of low-dimensional topology were presented in the workshop. Dani Wise opened the proceedings with a talk that outlined his proof with (Piotr) Przytycki that the fundamental groups of mixed 3-manifolds are virtually special. Groups were also the focus of talks by Stefan Friedl, Chris Leininger, and Ken Bromberg. Friedl surveyed his recent work with Silver and Williams on HNN splittings of knot groups. Leininger described his results with Dowdall and Kapovich on topological, geometric, and dynamical relations between monodromies of splittings of certain free-by-cyclic groups. Bromberg reported on joint work with Bestvina and Fujiwara determining necessary and sufficient conditions for the stable commutator length of an element in the mapping class group to be positive. Zhongtao Wu talked about the rational genus of knot in a 3-manifold, a topological quantity related to stable commutator length. In particular he discussed inequalities he determined with Ni using Heegaard-Floer homology, which imply, for instance, that simple knots in lens spaces are genus-minimizing in their homology class.

Saul Schleimer gave a new proof (joint with Wickens), based on the train-track machine, of Klarreich's theorem: the Gromov boundary of the curve complex is homeomorphic to the space of ending laminations. He explained how their proof generalizes to cover the Gromov boundary of the arc complex as well. Curve complexes were also central in Jesse Johnson's talk. He described how the notion of distance for a Heegaard splitting, and a slight generalization known as subsurface projection distance, can be used to construct a manifold with multiple distinct low-distance Heegaard splittings of the same (small) genus, and a manifold with both a high-distance, low-genus Heegaard splitting and a distinct, irreducible high-genus, low-distance Heegaard splitting.

The topology of geometric manifolds arose in several contexts. Jeff Brock described joint work with Minsky, Namazi, and Souto concerning a general framework for producing models for hyperbolic 3-manifolds with bounded combinatorial descriptions. He applied it to describe, for instance, a specific construction of homology 3-spheres Benjamini–Schramm converging to hyperbolic 3-space. The latter was a key component in the talk of Nathan Dunfield, who discussed his work with Brock on relations between growth in homology, L^2 homology, and injectivity radius in towers of hyperbolic 3-manifolds. Jessica Purcell outlined her studies on the following question: If a geometrically finite hyperbolic compression body has a single unknotting tunnel, is the tunnel isotopic to a geodesic? She conjectures the answer is yes. Genevieve Walsh's talk focused on her work with Hoffman on Thurston's Dehn-surgery graph of 3-manifolds. Along the way she explained their construction of the first examples of hyperbolic 3-manifolds with weight 1 fundamental groups that are not obtained via surgery on a knot in the 3-sphere.

In adjacent dimensions, Ian Biringer described the geometric limits of sequences of hyperbolic metrics on surfaces determined by iterations of certain homeomorphisms of the surface, giving a compressible version of examples due to Kerckhoff–Thurston, McMullen, and Brock. One highlight of the workshop was Alexander Kolpakov's description of his recent study with Martelli of the cusps of finite-volume hyperbolic 4-manifolds. In particular, they resolved a long-standing open problem by constructing the first examples of one-cusped such manifolds.

Analytic invariants of 3-manifolds have had a profound impact on 3-manifold topology through Ricci flow, Heegaard Floer homology, and contact topology over the last decade. Paolo Ghiggini described his foundational work with Colin and Honda on the isomorphism between Heegaard Floer homology and embedded contact homology. Josh Greene gave a talk of great clarity on his theorem that two reduced, alternating diagrams for a pair of links are mutants if and only if the Heegaard Floer homology of the link's branched double-covers are isomorphic.

Workshop
Impact of Climate Change on Biological Invasions and Population Distributions

May 12–17, 2013, BIRS

Sponsored by NSERC, the NSF, CONACYT, and the Ministry of Enterprise and Advanced Education of Alberta

Organizers:
Henri Berestycki (ÉHÉSS), Alan Hastings (UC Davis), Mark Lewis (Alberta), Péter Molnár (Princeton)
Speakers:
Henri Berestycki, Michael Bonsall (Oxford), Christina Cobbold (Glasgow), Chris Cosner (Miami), Kim Cuddington (Waterloo), Laurent Desvillettes (ÉNS Cachan), Odo Diekmann (Utrecht), Claire Dooley (Oxford), William Fagan (Maryland), Jimmy Garnier (INRA Avignon), François Hamel (Aix-Marseille; IUF), Alan Hastings, Amy Hurford (Memorial), Alex Kiselev (Wisconsin–Madison), Yuan Lou (Ohio State), Mark Lewis, Brett Melbourne (CU-Boulder), Ehud Meron (Ben Gurion), Péter Molnár (Princeton), Paul Moorcroft (Harvard), Lionel Roques (INRA Avignon), Luca Rossi (Padova), Rebecca Tyson (UBC Okanagan), Mary Lou Zeeman (Bowdoin Coll.), Ying Zhou (Washington), Huaiping Zhu (York)
Number of participants: 39

Summer School
Mathematics of Infectious Disease

May 19–27, 2013, York
Sponsored by the Fields Institute for Research in Mathematical Sciences and Mitacs

Organizers:
Jane Heffernan (York), Neal Madras (York), Seyed Moghadas (York), Jianhong Wu (York), Huaiping Zhu (York)
Public Lecture Speakers:
Carlos Castillo-Chavez (Arizona State), Mirjam Kretzschmar (Utrecht), Eduardo Massad (São Paulo)
Course Instructors:
Linda J. S. Allen (Texas Tech), Julien Arino (Manitoba), Fred Brauer (UBC), Odo Diekmann (Utrecht), David Fisman (Toronto), Jane Heffernan, Ying-Hen Hsieh (China Medical), Neal Madras, Seyed M. Moghadas, Beate Sander (PHO), Pauline van den Driessche (Victoria), James Watmough (New Brunswick), Ping Yan (PHAC), Huaiping Zhu

Workshop
Extremal Kähler Metrics

May 27–June 1st, 2013, CRM

Organizers:
Vestislav Apostolov (UQAM), Claudio Arezzo (ICTP), Xiuxiong Chen (Stony Brook), Claude LeBrun (Stony Brook)
Speakers:
Olivier Biquard (ÉNS), Xiuxiong Chen, Renjie Feng (McGill), Akito Futaki (Tokyo), Weiyong He (Oregon), Hongnian Huang (École Polytechnique), Chi Li (Princeton), Toshiki Mabuchi (Osaka), Sean T. Paul (Wisconsin–Madison), Yann Rollin (Nantes), Yuji Sano (Kumamoto), Cristiano Spotti (IHÉS), Ioana Suvaina (Vanderbilt), Christina W. Tønnesen-Friedman (Union Coll.), Hajime Tsuji (Sophia), Craig van Coevering (USTC), Jeff Viaclovsky (Wisconsin–Madison), Ben Weinkove (Northwestern)
Number of participants: 43

This one-week workshop, held at the Centre de recherches mathématiques, was focused on the study of the Calabi problem in Kähler Geometry. The workshop was attended by over 40 participants, ranging from algebraic geometers to differential geometers to analysts. Most participants were speakers and most attended every talk. Many new results were reported for the first time during the workshop and many participants left Montreal ready to work on new projects.

We highlight the two lectures series, one given by X. Chen and S. Sun (a total of three lectures) at the beginning of the workshop and the three Aisenstadt lectures given by G. Tian at the end of the workshop, in which the recent breakthrough in the Yau-Tian-Donaldson conjecture in the Fano case was presented. Other facets of the theory include the study of moduli of extremal Kähler metrics and desingularisations (talks by O. Biquard, J. Stoppa, I. Suvaina), Sasakian Geometry (talks by W. He, C. Tønnesen-Friedman, C. van Coevering), evolution equations in Kähler geometry (talks by A. Futaki, H. Huang, B. Weinkove), study of algebro-geometric notions of stability (C. Li, T. Mabuchi, Y. Rollin, S. Paul, Y. Sano), and probabilistic methods (R. Feng).

Thus, in an intensive week, the program succeeded in tying together most of the new results in the subject and a variety of new projects were born. The participants affirmed frequently and spontaneously that the program was a great success.

Summer School
The Mathematics Behind Biological Invasions

May 19–27, 2013, York

Sponsored by PIMS, the International Graduate Training Centre (IGTC) in Mathematical Biology, the Centre for Mathematical Biology, the University of Alberta, and Mathematics of Planet Earth 2013

Organizers:
Thomas Hillen (Alberta), Mark Lewis (Alberta)
Speakers:
Alan Hastings (UC Davis), Mark Lewis, Jonathan Sherratt (Heriot-Watt), Sergei Petrovskii (Leicester)

Workshop
Moduli Spaces and Their Invariants in Mathematical Physics

June 3–14, 2013, CRM

Organizers:
Jacques Hurtubise (McGill), Lisa Jeffrey (Toronto), Johannes Walcher (McGill)
Speakers:
Murad Alim (Harvard), Paul S. Aspinwall (Duke), Tom Baird (Memorial), Philip Boalch (ÉNS; CNRS), Vincent Bouchard (Alberta), Andrei Căldăraru (Wisconsin–Madison), Benoit Charbonneau (St. Jerome), Sergey Cherkis (Arizona), Andrew Dancer (Oxford), Keshav Das Gupta (McGill), Tudor Dan Dimofte (IAS), Ron Donagi (Pennsylvania), Charles Doran (Alberta), Brent Doran (ETH Zürich), Bertrand Eynard (CEA/Saclay), Jonathan Fisher (Toronto), Davide Gaiotto (Perimeter Inst.), Peng Gao (Stony Brook), Marco Gualtieri (Toronto), Babak Haghighat (Harvard), John Harnad (Concordia), Tamas Hausel (EPFL), Spiro Karigiannis (Waterloo), Matt Kerr (WUSTL), Boris Khesin (Toronto), Can Kozcaz (SISSA), Joshua Lapan (McGill), Chiu-Chu Liu (Columbia), Alexander Maloney (McGill), Eckhard Meinrenken (Toronto), Ruxandra Moraru (Waterloo), Hiraku Nakajima (Kyoto), Tony Pantev (Pennsylvania), Brent Pym (Toronto), Steven Rayan (Toronto), Mauricio Romo (Kavli Inst.), Jihye Seo (McGill), Vivek Shende (UC Berkeley), Jörg Teschner (Hamburg), Valerio Toledano Laredo (Northeastern), Misha Verbitski (Glasgow), Michael Lennox Wong (EPFL), Kota Yoshioka (Kobe), Matthew B. Young (Stony Brook)
Number of participants: 71

Moduli spaces appear in a variety of contexts in both mathematics and physics. In physics, they are often, in some sense, the natural spaces for functional integration, after one has quotiented out infinite dimensional spaces of symmetries; in mathematics, they exhibit a bewildering array of structure, whose discovery is often due to intuition from physics. The two-week-long extended workshop, Moduli Spaces and their Invariants in Mathematical Physics, held June 2 to 14th, 2013, was a true meeting of cultures, with all the fruitful interaction (and occasional frustration) that this implies. It provided an opportunity to see the wide variety of themes that interplay in the area. Within the limits of the availabilities of the different speakers, the conference organised itself around some of these themes, alternating in a rough fashion between more mathematical topics and more physical ones. These include:

- *Metrics with special holonomy.* On these, we saw deep and interesting results on hyperkähler manifolds presented by Andrew Dancer, Sergey Cherkis, on G2 structures by Spiro Karagiannis, and on hypercomplex structures by Misha Verbitsky. Tamas Hausel gave some very interesting computational evidence on the Betti numbers of hyperkähler manifolds.
- *Calabi–Yau manifolds, their moduli, and their invariants.* The geography of the Calabi–Yau moduli was explored in various aspects by both Paul Aspinwall and Charles Doran. Around the general theme of toric Calabi–Yau and the Bouchard–Klemm–Marino–Pasquetti conjecture on their relation to the Eynard–Orantin invariants, Bertrand Eynard gave his explanation and proof for smooth varieties, and both Melissa Liu and Vincent Bouchard explained the extension to orbifolds. John Harnad gave a survey of various appearances of the tau function in the computation of numerical invariants. In a related theme, Tony Pantev talked about the complex moduli of Landau–Ginsburg models.
- *Symplectic geometry and integrable systems.* In some sense, this is a more classical part of the story, but with some beautiful surprises: Jonathan Fisher gave a talk on analogues of polygon spaces, and Boris Khesin explained his generalizations of pentagram maps. Vivek Schende told us about Legendrian knots, and Eckhard Meinrenken explained how we should understand the Verlinde formulae for non-simply connected groups.
- *Non-Kähler geometry.* In this emergent area, Ruxandra Moraru explained some gauge-theoretical work

on balanced HKT manifolds, and Andrei Căldăraru spoke on moduli of sheaves on non-Kähler manifolds.

- *Wild character varieties and Stokes phenomena.* While this is in some ways the most classical area of all the conference, a clear understanding of the Stokes phenomenon is only just emerging. Marco Gualtieri and Brent Pym explained their new groupoid approach to wild character varieties, Michael Wong gave a talk on the arithmetic aspects of these varieties, and Philip Boalch's wide-ranging survey explained some rather subtle isomorphisms that take place.
- *Gauge theory.* The conference opened with a beautiful talk by Hiraku Nakajima, explaining some of the support for the Alday-Gaiotto-Tachikawa (AGT) conjecture on the cohomology ring of instanton moduli spaces; Kota Yoshioka explained some results on Bridgeland stability and stable sheaves on abelian surfaces; Benoit Charbonneau talked about various aspects of the Nahm transform for spatially periodic instantons, Tom Baird on the real aspects of moduli of vector bundles over a curve, and Steven Rayan talked on the moduli of twisted Higgs bundles.
- *Moduli of curves.* This other central topic was well represented by the talks of Ron Donagi, who explained his rather surprising result with Witten on the structure of supermoduli space, of Brent Doran, who talked about moduli of stable rational curves, and Jihye Seo explaining some of the physical aspects of the degeneration of hyper-elliptic curves.
- *Algebraic aspects of moduli.* There are quite rich algebraic structures underlying all of these moduli spaces, and some of these appeared in the talks by Valerio Toledano Laredo ("From Yangians to quantum loop algebras via abelian difference equations") and Matthew B. Young (Hall modules of quivers).
- *Computation of Gromov-Witten Invariants.* One exciting recent development in invariants of moduli spaces is supersymmetric localization, amongst others as a tool for computation of Gromov-Witten invariants, without mirror symmetry; Joshua Lapan reviewed the closed string story and Mauricio Romo explained the generalization to open strings.
- *Quantization and topological strings.* Quantization of moduli spaces and the associated integrable systems is a notoriously difficult topic of recurring interest. Jörg Teschner explained the quantization of moduli of curves as suggested by the AGT relation to gauge theory. Moving to higher dimensions, Murad Alim revisited the structure of Bershadsky-Cecotti-Ooguri-Vafa rings on moduli of Calabi-Yau threefolds that are analogous to quasi-modular forms. Matt Kerr discussed the invariants of algebraic cycles that play a fundamental role at the semi-classical level.
- M-theory: Supersymmetric localization and the AGT correspondence are but two topics showcasing the impressive progress in the physical calculation of invariants of moduli spaces in various corners of M-theory. Babak Haghighat presented his recent work on a variant correspondence, with different amounts of supersymmetry and firmly rooted in M-theory. Can Kozcaz calculated the elliptic genus of M2-branes suspended between M5-branes.
- Applications: We invited several talks on applications of moduli spaces for concrete physical questions in string theory. From the side of the heterotic string, Peng Gao discussed questions of stability in various classes of bundle constructions on Calabi-Yau threefolds. Keshav Dasgupta took first steps in the exploration of gauge/gravity duality in that heterotic theory. Alex Maloney exposed the relation between 3D quantum gravity and a number of challenging problems in moduli of Riemann surfaces.

The conference opened on a mathematical theme, with the talk by Hiraku Nakajima; on the other hand, both weeks closed on a strongly physical note, with Alex Maloney in the first week, and Keshav DasGupta in the second. The conference moved for one day out to Mont Saint Hilaire, with talks in the morning and an exploration of the Nature Reserve in the afternoon, with of course more discussion taking place under the stimulation of exercise; the weather gods smiled on us with one of the few sunny days in an otherwise rather rainy two weeks. One nice aspect of the conference was a strong participation by post-doctoral fellows, whose presence was greatly helped by funding from the NSF, to whom we are grateful.

Workshop
Low-Dimensional Topology after Floer

July 8–12, 2013, CRM

Organizers:
Hans Boden (McMaster), Olivier Collin (UQAM)
Speakers:
Kenneth Baker (Miami), John Baldwin (Boston Coll.), Vincent Colin (Nantes), Christopher Cornwell (Duke), John Etnyre (Georgia Tech), Kim A. Froyshov (Aarhus), Paolo Ghiggini (CNRS; Nantes), Elisenda Grigsby

(Boston Coll.), Matthew Hedden (Michigan State), Ko Honda (Southern California), Michael Hutchings (UC Berkeley), Paul Kirk (IU Bloomington), Ciprian Manolescu (UC Los Angeles), Lenhard L. Ng (Duke), Jacob Rasmussen (Cambridge), Nikolai Saveliev (Miami), Clifford Taubes (Harvard), Stefano Vidussi (UC Riverside)

Number of participants: 76

The conference focused on the current impact of Floer homology methods in low-dimensional topology. In recent years, the interactions between geometric, contact, and symplectic topology and the many types of Floer homologies have proved very successful for solving outstanding questions in low-dimensional topology, and there are signs that more breakthroughs will occur in the near future. This event brought together leading experts working in these related areas, but also a special emphasis was put on the invitation of up-and-coming researchers and graduate students, some of whom also attended the SMS summer school on the mathematics and physics of knot homologies (summarized in the CRM annual report for the year 2013–2014).

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.

January–July 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)

General Program

The CRM's general program 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. *The reports are presented in the language in which they were submitted.*

CRM activities

The 23rd International Meeting on Probabilistic, Combinatorial and Asymptotic Methods for the Analysis of Algorithms (AofA 2012)

June 18–22, 2012, CRM
Sponsored by the CRM, INRIA, and NSERC

Organizers:
Nicolas Broutin (INRIA Rocquencourt), Luc Devroye (McGill)
Plenary Lecturers:
Amin Coja-Oghlan (Warwick), Michael Drmota (TU Wien), Svante Janson (Uppsala), Claire Mathieu (Brown, CNRS, and ÉNS), Avi Wigderson (IAS)
Number of participants: 72

The conference consisted of 5 invited talks by distinguished researchers in the field of algorithms and combinatorial structures: Amin Coja-Oghlan, Michael Drmota, Svante Janson, Claire Mathieu, and Avi Wigderson; and 32 presentations that had been selected by the program committee after submission of a 12-page abstract.

The meeting is part of a series of conferences and workshops that has been going on for more than two decades. It aims at providing a venue for the people working in the field of theoretical computer science or discrete mathematics in order to present the recent advances, exchange ideas, and foster new contacts and collaborations about the asymptotic behaviour of random combinatorial structures and their applications to the analysis of algorithms and data structures. The participants have mixed backgrounds going from combinatorics and complex and asymptotic analysis to probability theory and stochastic processes.

It is remarkable that the meeting at the CRM showed increasing signs that the community is blending: in particular, the different groups on which the meeting traditionally relies (analysts, combinatorists, probabilists) are now certainly more porous than they used to be. We were glad to see that the proportion of students and young researchers had not declined, in spite of the distance to Europe where most of the community lies.

This year's meeting was especially successful with talks covering a broad range of topics in algorithms or data structures, combinatorics, discrete probability, or methodology. All the talks were very lively and provided interesting and new points of view on important questions or novel applications. A number of open problems were raised, in particular by the invited speakers, some of which are traditionally chosen in neighbouring fields in order to provide the participants with an alternative point of view on the important current directions of research in algorithms and random structures.

On the topics of algorithms, two of the invited speakers delivered wonderful lectures on approximation algorithms (C. Mathieu) and learning (A. Widgerson) which raised many questions and open problems. J. Gaither presented new results on the number of protected nodes in random tries and suffix trees, which have implications on the performance of algorithms manipulating strings. Probabilistic counting and its applications were addressed in the talks by M. Fuchs and C. Martinez. O. Roussel presented extensions to shuffle products of the widely used Boltzmann samplers. D. Shymura discussed geometric algorithms for shape matching of surprising simplicity that rely on random sampling. C. Fricker demonstrated that the methods can be applied to other concrete problems such as bike sharing systems (BIXI, Vélib'). The other talks on algorithms included B. Vallée's demonstration that Euclid's algorithm is totally Gaussian, J. Fill's recent work on the performance of Quicksort measured in number of symbol comparisons, Z. Golebiewski's new analysis of leader election based on the trie data structure, E. Gassiat's work on lossless compression via adaptive coding for countable alphabets, and I. Eisner's application of domination analysis to scheduling problems.

Discrete probability was addressed in S. Janson's invited lecture on branching processes. Random trees

and their properties were also the main topic of the talks by S. Wagner on additive functionals with small toll functions, and V. Kraus on transversals in random trees, which is very surprisingly inspired from applications to antiterrorism. S. Miracle discussed the mixing time of Markov chains on planar triangulations. Urn models and their asymptotic behaviour were the topic of the talks of B. Mocrette (random balanced urns) and M. Kuba (diminishing urns via death processes). G. Fayolle presented his results with K. Raschel on the number of random walks constrained to live in the quarter plane, which has generated much interesting research since the proof that the generating function for Gessel's walk is algebraic. Y. Ponty discussed the word collector, a model inspired by the sampling of protein configurations. L. Lhote discussed hidden patterns in strings under general models of sources.

More combinatorial themes were also addressed in M. Drmota's invited lecture on universal results on subcritical random graphs, and A. Coja-Oghlan's introduction to the currently hot topic of phase transitions in random structures and their connection to hardness of optimization problems. Some interesting new aspects of essential combinatorial structures were presented by D. Ralaivaosaona (integer partitions), V. Feray (random partitions), Z. Gao (random compositions), and P. Jacquet (joint string complexity). The talks on combinatorics also included discussions of less mainstream problems such as random subgroups of a free group (F. Bassino), random polyominos in relation to Stokes phenomenon in complex analysis (L. Hickok), and min-weight digital expansions (C. Heuberger).

Moreover, new methodological advances were presented by W. Spzankowski on the asymptotic of solutions of binomial recurrences, J. Cichon on Bernoulli sums, and J. Kieffer on divide-and-conquer recurrences. Furthermore, B. Gittenberger discussed his very recent and far reaching results on Gaussian limit distributions for the solutions of infinite systems of equations. These advances will certainly be central to a number of applications in combinatorics in the future.

Finally, the authors of abstracts published in the conference have been offered the opportunity to submit long versions of their work to a special issue of the journal "Combinatorics, Probability and Computing," which will be dedicated to the memory of Philippe Flajolet in connection with AofA 2012. This special issue edited by N. Broutin (INRIA), J. Fill (Johns Hopkins), Markus Nebel (Kaiserslautern), and M. D. Ward (Purdue) will gather the best contributions and confirm the success of the conference held at the CRM.

Workshop
$\mathcal{N} = 2$ Jeometry and ApplicationZ

June 20–22, 2012, McGill
Sponsored by the Mathematical Physics Laboratory

Organizers:
Keshav Dasgupta (McGill), Jihye Seo (McGill), Johannes Wacher (McGill)

Speakers:
Philip Argyres (Cincinnati), Chris Beem (Simons Ctr.), Clay Cordova (Harvard), Jacques Distler (UT Austin), Amihay Hanany (Imperial Coll.), Ken Intriligator (UC San Diego), Peter Koroteev (Minnesota), Daniel Krefl (UC Berkeley), David Kutasov (Chicago), Satoshi Nawata (Perimeter Inst.), Chan Youn Park (Caltech), Ramadevi Pichai (IIT Bombay), Shlomo Razamat (IAS), Nathan Seiberg (IAS), Sav Sethi (Chicago)

Number of participants: 19

Supersymmetric theories with 8 supercharges (this being $\mathcal{N} = 2$ times the minimal amount required for 4-dimensional Lorentz invariance) are models of relativistic quantum physics that both have nontrivial perturbative and nonperturbative dynamics, and are amenable to exact analysis. Ever since the celebrated solution of $\mathcal{N} = 2$ supersymmetric gauge theory by Seiberg and Witten, the investigation of the rich underlying geometric structure together with its embedding into string theory has proven remarkably fruitful. These developments first of all triggered the discovery of dualities in string theory itself. Secondly, they resulted in an impressive amount of results of relevance to pure mathematics. Thirdly, they have been the starting point for many of the more convincing recent attempts to reconstruct particle physics from a fundamental theory, by breaking $\mathcal{N} = 2$ to $\mathcal{N} = 1$ supersymmetry with branes and fluxes. The last three years have witnessed an impressive revival of interest in $\mathcal{N} = 2$ theories. Among recent results that motivated this workshop, we mention the presentation of a new class of superconformal theories by Gaiotto, their correspondence with certain 2-dimensional (bosonic) conformal theories of Liouville type, as well as the "Nekrasov–Shatashvili" relation between Ω-deformed $\mathcal{N} = 2$ theories and quantum integrable systems, and the embedding of all of the above within string theory.

The scope of the workshop (as hinted by the title) was somewhat larger and included also supersymmetric field theories in other dimensions, and with different amounts of supersymmetry. This framework brought together a number of established researchers, including several of the pioneers, and representatives of the new generation who entered the field in recent years. The goal was to provide a forum for discussion of recent results in the light of original methods and ideas.

The workshop was hosted by the McGill physics department, and the format was modelled after several other successful events organized by McGill's Centre for High Energy Physics about three to four times a year: two and a half days with around 15 external speakers in a relaxed atmosphere with ample time for discussions. Such a format represents a particular benefit for graduate students around Montréal, who have the opportunity to meet and interact with distinguished scholars in their chosen field of study. As confirmed by many of the participants, the organizers succeeded in striking the right balance this time again. Progress in this branch of mathematical physics is expected to continue at the same amazing pace, and everyone left Montréal looking forward to a future meeting.

Summer School
Séminaire de Mathématiques Supérieures 2012
Probabilistic Combinatorics

June 25–July 6, 2012, CRM

Sponsored by the Fields Institute for Research in Mathematical Sciences, PIMS, the CMS, the Université de Montréal, the MSRI, and the CRM

Organizers:

Louigi Addario-Berry (McGill), Luc Devroye (McGill), Bruce A. Reed (McGill)

Speakers:

Nikhil Bansal (TU Eindhoven), Hamed Hatami (McGill), Penny Haxell (Waterloo), James R. Lee (Washington), Colin McDiarmid (Oxford), Yuval Peres (Microsoft Res.), Alex Scott (Oxford), Perla Sousi (Cambridge), Prasad Tetali (Georgia Tech), Eric Vigoda (Georgia Tech), Peter Winkler (Dartmouth Coll.)

Number of participants: 81

The 2012 Séminaire de Mathématiques Supérieures introduced nearly eighty young researchers from eastern and western Canada, the USA, Australia, Belgium, Brazil, the Czech Republic, England, France, Germany, Hungary, India, the Netherlands, and Sweden, to some of the most exciting subjects of active research in the area of probabilistic combinatorics. The subjects addressed at the summer school can be roughly arranged into two overlapping themes:

(1) properties of discrete Markov chains; and
(2) new techniques for understanding structural properties of deterministic and random graphs.

The majority of the eleven invited speakers stayed for at least one full week of the SMS, and four of the speakers (Hatami, McDiarmid, Scott, Winkler) stayed for both weeks. This gave the students plenty of opportunity to interact with the speakers outside of the lecture hall, which contributed substantially to the scientific quality of the meeting. (For example, one speaker, Prasad Tetali, ended up giving a supplementary "mini-course" to a subset of the students who were interested in hearing more detail about some of the research Tetali touched on in his lectures.)

THEME 1: DISCRETE MARKOV CHAINS

The flagship lectures on this theme were by Peter Winkler, who gave a sequence of five ninety-minute talks on random walks on graphs. This (by now) classical subject has lots of beautiful theorems and scores of applications in mathematics and computer science. Nonetheless, new and remarkable results keep coming in. Winkler started by reviewing the classical results in the area, including the connection between random walks and electrical networks and its extensions. He then moved to some exciting new research, including recent results and open problems on covering the vertices and edges of a graph, the use of potential functions to prove universal bounds for cover times, and cat-and-mouse (or cop-and-robber) games on graphs. James Lee's talks dovetailed beautifully with Winkler's, while consisting of more classically probabilistic content. Lee presented his recent tour de force with Ding and Peres, relating the cover time of reversible Markov chains to the extremes of an associated Gaussian process. This research has now appeared in the Annals of Mathematics. Lee provided a brief background on Gaussian processes and beautifully presented Talagrand's majoring measures theorem. He then explained how he, Ding, and Peres used the majorizing measures theory to exhibit a close connection between the cover time of a graph and the expected square of its Gaussian free field.

The main tool allowing results for the Gaussian free field to be transferred to the setting of Markov chains is

the Dynkin isomorphism theory for Markov processes. While this connection is extremely useful and has already resulted in solutions to some open questions on cover times, it is also rather mysterious even in extremely simple examples. Lee discussed some natural starting points for possible research into the deeper structure behind the Dynkin theory. Prasad Tetali's talks, on geometric and functional analysis on graphs, were conceptually linked to those of James Lee via the connection between isoperimetric inequalities and extremes of Gaussian processes. Tetali began with a review of some classical isoperimetric and functional inequalities in discrete spaces, with applications to concentration of measure and convergence to equilibrium of finite Markov chains. He then presented recent results on generalizations of Cheeger-type inequalities and refinements of Brunn-Minkowski inequalities, which suggest new directions for interesting research in geometric and functional analysis on graphs. Perla Sousi presented her recent result, joint with Yuval Peres (and independently proved by Roberto Oliveira) on the equivalence of a broad family of notions of mixing time. Most notable among these is the fact that for reversible Markov chains, the mixing time is equivalent to the hitting time of large sets. This easily-stated fact provides a robust equivalent of the mixing time that can be used both to simplify many existing proofs and to derive new results. Sousi highlighted one such result, related to a geometric characterization of the mixing time for random walks on trees.

Yuval Peres's lectures were on the subject of random walks on infinite graphs, which despite being more classical is still rife with open problems and areas where our understanding is incomplete. At the outset, Peres motivated his lectures with the following question: which of the following random walks on Z_2 are transient and which are recurrent?

(1) In $\mathbb{Z}_2$, at times $t \in [4^k, 2{\cdot}4^k)$ we go up or down with equal probability. At times $t \in [2{\cdot}4^k, 4^{k+1})$, we go left or right with equal probability.
(2) In $\mathbb{Z}_2$, if the current node has been visited before, then move left or right with equal probability; otherwise go up or down with equal probability.
(3) In $\mathbb{Z}_2$, if $|x| \geq |y|$ then we go up or down each with probability 0.3, and left or right each with probability 0.2. This is reversed if $|y| > |x|$.
(4) In $\mathbb{Z}_3$, fix two mean-zero measures μ_1, μ_2 that are truly 3D (that is, neither μ_1 nor μ_2 assigns probability 1 to any hyperplane) with bounded support. If X_t has been visited before, then $X_{t+1}{-}X_t \sim \mu_2$, else $X_{t+1}{-}X_t \sim \mu_1 1$.

(It turns out that 1, 3, and 4 are transient, and it is an open problem to determine transience or recurrence for number 2.) Peres then presented a wide range of questions and results on transience, recurrence, and speed of random walks on various models of infinite graphs, with a particular focus on highlighting basic gaps in our conceptual understanding and current techniques. Finally, Eric Vigoda's talks formed a bridge between the first and second themes, presenting results related to Markov Chain Monte Carlo algorithms for generating random colourings of graphs of bounded degree. Vigoda explained the basic coupling technique, and its refinement – known as path coupling – due to Bubley and Dyer. He then explained the well-known result of Mark Jerrum on rapid mixing of the Glauber dynamics for colouring when the number of colours exceeds twice the maximum degree Δ. Vigoda followed this up with various improvements, beginning with his own famous result showing rapid mixing for the Glauber dynamics with $11\Delta/6$ colours, via the analysis of a more complicated chain that flips 2-colour components. He also showed how a multi-step coupling can be used to get improved results (assuming lower bounds on the girth and on the maximum degree, Δ). Finally, he explained a beautiful use of spectral graph theory to obtain improved results for planar graphs or graphs embeddable on a fixed surface.

THEME 2: COLOURINGS, CLIQUES, AND CONNECTIVITY

Many questions in combinatorics concern the relationship between the local and global structure of a graph or set system. For instance, what can we say about the subgraphs of a graph with large chromatic number? What about graphs without large cliques or independent sets? How uniformly is it possible to distribute edges in a graph? In 7.5 hours of lectures, Alex Scott presented a wide range of results and conjectures of this flavour, touching on the Erdős-Hajnal Conjecture, the Gyárfás-Sumner Conjecture, discrepancy for graphs and hypergraphs, and recently developed VC-dimension techniques. Nikhil Bansal gave another extended mini-course of 7.5 hours, which brought the participants to the edge of existing knowledge in discrepancy theory. Discrepancy theory deals with the following type of question. Given a set-system, find a red-blue colouring of the elements such that each set is coloured as evenly as possible. Perhaps surpris-

ingly, this notion has a wide variety of applications both in computer science and mathematics, and several techniques (many of them non-constructive) have been developed to understand the discrepancy of various set-systems. Recently, there have been several new developments in discrepancy based on connections to semidefinite programming. This connection is useful is various ways. It gives efficient polynomial-time algorithms for several problems for which only non-constructive results were previously known. It also leads to several new structural results, such as the tightness of the so-called determinant lower bound, and bounds on the discrepancy of unions of set-systems. Bansal presented these results in detail and touched on several related concepts such as correlated Brownian motions, the non-constructive entropy method, Gaussian rounding, and SDP duality.

Penny Haxell's lectures had the intriguing title "a topology-free topological method." Over the last dozen years or so, certain topological methods have been developed and used to prove a family of results related to the following general problem. Let G be a graph whose vertex set is partitioned into nonempty sets $V_1, \ldots, V_r$. What conditions will guarantee that G contains an independent set $\{v_1, \ldots, v_r\}$ such that $v_i \in V_i$ for each i? This family of results includes theorems on matchings in hypergraphs, list colouring, strong colouring, and Aharoni's proof of Ryser's longstanding conjecture on packing and covering in tripartite hypergraphs. The topological arguments used are based on the notion of topological connectivity of simplicial complexes. Haxell has recently developed a method for establishing this entire theory using only elementary combinatorial arguments, and this approach was the subject of her SMS lectures.

Colin McDiarmid presented some recent breakthroughs on a classic question in probabilistic graph theory: what is the typical behaviour of the chromatic number $\chi(G)$ of a graph G? If R_n denotes some sort of random graph on n vertices, can we determine a function $f(n)$ such that $\chi(R_n)/f(n) \to 1$ in probability as $n \to \infty$? If so, what is $f(n)$? Can we bound the typical spread of the values $\chi(R_n)$? Is $\chi(R_n)$ usually close to $\omega(R_n)$, the maximum size of a complete subgraph? McDiarmid presented a variety of his recent results; his lectures focused primarily on the classical Erdős-Rényi or Bernoulli random graph $G(n, p)$ (both in the dense case where p is a constant and in the sparse case where np is constant), and on random geometric graphs. He also touched on other graph invariants such as edge-chromatic number (chromatic index), list chromatic number, total chromatic number, achromatic number, improper chromatic number, and span. Perhaps most notably, he presented a recent technique that yields improved estimates for $\chi(G(n, p))$ in the dense case, and a surprising "phase change" that occurs when colouring random geometric graphs.

The subject of influences is key to the understanding of phase transitions and sharp thresholds for various properties of discrete systems, including colouring of graphs, satisfiability of random formulas, and connectivity of random networks. Hatami presented the basic notion of the influence of a variable on a Boolean function, then sketched the proof of the Friedgut's theorem stating that if $f : \{0,1\}^n \to \{0,1\}$ has small total influence then it essentially depends on few coordinates. This theorem does not hold when the uniform distribution on $\{0,1\}^n$ is replaced with the p-biased distribution for a small value of p. He discussed the relevance of this case to the study of the threshold phenomenon, and then sketched the proof of his own recent result, which characterizes the structure of Boolean functions with small total influences on general product probability spaces. The latter result has garnered substantial attention and has recently appeared in the Annals of Mathematics.

2nd Conference GNU Octave [free your numbers]

July 16–20, 2012, CRM
Sponsored by the CRM and the Université de Montréal

Organizer: Jordi Gutiérrez Hermoso
Number of participants: 20

GNU Octave is a free software that is quite similar to Matlab and thus includes algorithms for the numerical solution of linear and nonlinear problems. It allows one to perform other numerical experiments as well and provides extensive graphics capabilities for data visualization and manipulation. Octave is a high-level interpreted language but can also be used to write non-interactive programs. OctConf2012, which took place at the CRM in July 2012, is part of a series of workshops geared towards people with an interest in Octave. The workshop was very successful. Over the course of five days, twenty participants were involved, and all but two were at the workshop for at least four days. The goal of the first two days was to provide information and the latest updates on development

methodologies. The next three days consisted of open discussion and development. The schedule was followed with almost no modification. We refer the reader to http://jordi.inversethought.com/blog/octconf-2012-report/ for more details. The following talks took place:

(1) What is Octave? (Jordi Gutiérrez Hermoso)
(2) Octave's architecture (Jordi Gutiérrez Hermoso)
(3) Status of Octave (John W. Eaton)
(4) Octave Speed and Cell Arrays (Daniel Sebald)
(5) JIT Compiler (Max Brister)
(6) The Octave GUI (Jacob Dawid)
(7) Agora Octave and Packaging (Carlo de Falco, David Pinto, and Juan Pablo Carbajal)
(8) Bringing Least-Squares Spectral Analysis to Octave (Ben Lewis)
(9) BIM package (Carlo de Falco)

Mini-courses & Workshop
Coxeter Groups Meet Convex Geometry

August 13–17 and 20–22, 2012, UQAM
Sponsored by LaCIM

Organizers:
Christophe Hohlweg (UQAM), Jean-Philippe Labbé (UQAM), Carsten Lange (FU Berlin), Vivien Ripoll (UQAM)

Lecturers:
Matthew Dyer (Notre Dame), Christophe Hohlweg, Carsten Lange, Vincent Pilaud (École Polytechnique)

Number of participants: 30

There are numerous examples of relations between convex geometry and Coxeter groups, the most known probably being the construction of the Tits cone. During these last years, many interesting other examples have been thoroughly studied, among them: generalized associahedra and permutahedra of finite reflection groups; Cambrian fans; brick polytopes and multiassociahedra; imaginary cones and infinite root systems.

These nice encounters between Coxeter groups and convex geometry have two main consequences: we manage to understand better the combinatorics and geometry of Coxeter groups by encoding some of their characteristics in polytopal or more general convex constructions; we also obtain new families of interesting polytopes, which is very useful in convex geometry since such families are fairly rare.

The aim of this meeting was to bring together experts and interested people from both communities, in order that they learn from one another and discuss together new avenues that can be explored. The first week of the meeting was dedicated to minicourses, while the second week was organized to encourage collaborations and discussions.

About 30 researchers coming from Europe (France, Italy), Australia, or North America (Canada and USA) attended both the minicourses and the workshop. We were very pleased to see that the objectives we set were reached: many collaborations started during this meeting, and a second "Coxeter groups Meet Convex Geometry" meeting will be organized within two years most certainly in Europe.

Infinite-Dimensional Lie Theory: Algebra, Geometry and Combinatorics
A CRM–Fields Institute Workshop

August 21–24, 2012, CRM

Organizers:
Joel Kamnitzer (Toronto), Michael Lau (Laval)

Speakers:
Ibrahim Assem (Sherbrooke), Bojko Bakalov (North Carolina State), Ivan Dimitrov (Queen's), Christopher Dodd (Toronto), Alex Feingold (Binghamton), Dennis Gaitsgory (Harvard), Nicolas Guay (Alberta), Sam Gunningham (Northwestern), Andrew R. Linshaw (Brandeis), Pierre Mathieu (Laval), Ivan Mirkovic (UMass Amherst), Dinakar Muthiah (Brown), Shifra Reif (Michigan), Hadi Salmasian (Ottawa), Hugh Thomas (New Brunswick), Peter Tingley (MIT & Loyola), Jethro van Ekeren (MIT & IMPA)

Number of participants: 42

Infinite-dimensional representations of Lie algebras and related structures play a vital role in a broad swath of modern mathematics, including vertex algebra theory, quantum groups, quivers and cluster algebras, geometric representation theory, conformal field theory, and the Langlands programme. The jointly sponsored CRM–Fields workshop brought together an energetic group of more than 40 researchers approaching the subject from a variety of algebraic, geometric, and combinatorial points of view.

The first day of the conference featured combinatorial aspects of infinite-dimensional Lie theory. Ivan Dimitrov explained how some completely elementary combinatorial objects, *inversion sets*, can be used to understand difficult geometric and combinatorial problems like the vanishing of the cup product on coho-

mology of flag varieties in Bott–Borel–Weil, and the determination of Littlewood–Richardson coefficients. Hugh Thomas presented a natural bijection between certain subcategories of representations of the path algebra of a Dynkin quiver and elements of the corresponding Weyl group. Ibrahim Assem introduced the notion of a *cluster automorphism* and connected this definition with the mapping class group of marked, oriented Riemann surfaces. Peter Tingley and Dinakar Muthiah gave well-motivated introductions to the subject of affine Mirkovic–Vilonen polytopes and how they give a dictionary between Lusztig data associated with crystal bases.

The second day of the conference focused on vertex algebras and their applications. Pierre Mathieu gave a super-extension of Jack polynomials, eigenfunctions of the Sutherland Hamiltonian that parametrize singular vectors in highest weight modules of the Virasoro Lie algebra. Andy Linshaw discussed a vertex operator analogue of Hilbert's theorem on finite generation of invariant rings under a reductive group action. Jethro van Ekeren presented his recent results on modular invariance of spaces of twisted characters for vertex superalgebras of nonintegral conformal weight. Bojko Bakalov used the *total descendent potential*, a generating function for Gromov–Witten invariants, to give a McKay-like relation between Kleinian singularities and representations of W-algebras. Alex Feingold used vertex operator techniques to calculate affine branching rules for inclusions given by Dynkin diagram folding.

The final two days of the conference emphasized geometric representation theory, Lie supergroups, and Lie superalgebras. Dennis Gaitsgory outlined the proof of the geometric Langlands conjecture for $\mathrm{GL}(2)$, taking care to point out the easy and difficult parts of the proof along the way. Sam Gunningham explained results concerning the cohomology of the character variety of a reductive group. Chris Dodd gave a quick review of Nakajima quiver varieties before describing a way to categorify Lie algebra actions on quiver varieties using D-modules. Ivan Mirkovic presented Lusztig's conjectures in modular representation theory and explained how to resolve them using localization, and Nicolas Guay explained how to construct vertex operator representations for Yangians associated with affine Lie algebras. Hadi Salmasian surveyed analytic properties of infinite-dimensional Lie supergroups and showed how to construct some of their unitary representations, and Shifra Reif presented her results on denominator identities for affine Lie superalgebras at critical level and some of their interesting applications.

One of the goals of this jointly sponsored CRM–Fields conference was to bring together the Lie theory community of central Canada. It is a tribute to the quality and quantity of Lie theory in the region that such a high-quality conference could be held at the CRM with a solid majority of participants arriving from universities in Ontario, Québec, and the northeast USA. A remarkable feature of the conference was the relative youth of the participants. Seven of the sixteen invited speakers were graduate students or postdoctoral fellows. They and a number of enthusiastic audience members made it a memorable week filled with some fantastic mathematics.

Colloquium
Entretiens Jacques-Cartier
Mathématiques appliquées à la gestion des risques

November 19–20, 2012, Lyon 1
Sponsored by the CNRS, the CRM, ISFA (Lyon 1), AMIES, and the Mprime network

Organizers:
Christophette Blanchet-Scalliet (École Centrale de Lyon), José Garrido (Concordia), Laurent Habsieger (CNRS & CRM), Stéphane Loisel (Lyon 1), Manuel Morales (Montréal), Pierre Ribereau (Lyon 1)
Speakers:
Patrice Bertail (Paris Ouest), Juliette Blanchet (EPFL), Nicolas Brisebarre (ÉNS Lyon), Rama Cont (CNRS & LMPA), Anne-Béatrice Dufour (Lyon 1), Bruno Dupire (Bloomberg), Nicole El Karoui (UPMC), Max Feinberg (INRA-Paris), Alexis Hannart (CNRS & IFAECI), Monique Jeanblanc (Évry), Jacques Légaré (Montréal), Marc-André Lewis (CDPQ), Étienne Marceau (Laval), Guy Métivier (Bordeaux 1), Pietro Millossovich (City, London), Didier Sornette (ETH Zürich), Leroy Stone (Montréal)

Les vingt-cinquièmes Entretiens Jacques-Cartier se sont tenus à Lyon les 19 et 20 novembre 2012, et plus de 50 participants étaient présents. Les organisateurs de la France étaient Christophette Blanchet-Scalliet, Stéphane Loisel et Pierre Ribereau, et les organisateurs du Québec étaient José Garrido, Laurent Habsieger et Manuel Morales. Plus globalement, les Entretiens Jacques-Cartier sont organisés chaque année à la fois par des Français et des Canadiens. Leur vocation

est de rapprocher des intervenants issus de milieux qui ne se côtoient pas habituellement. Ils sont articulés autour de quatre grands axes : économique et politique, scientifique, social et culturel.

Le but de ce colloque était d'être un lieu de rencontre où les groupes de recherche industriels et académiques pourraient trouver un environnement propice à la discussion scientifique et aux échanges interdisciplinaires sur le thème de la gestion quantitative des risques (en particulier actuariels, financiers, climatiques, environnementaux, de sûreté des calculs, sanitaires et biotechnologiques). L'objectif principal du colloque était donc de rapprocher ces deux types d'acteurs et d'encourager les interactions entre eux: d'un côté, les interventions faites par des chercheurs industriels ont donné un aperçu des problèmes d'actualité, des outils et des méthodes utilisés en pratique, et de l'autre, la participation des chercheurs universitaires a apporté à la discussion les nouvelles méthodes et modèles récemment développés.

Les sessions et tables rondes du colloque portaient à la fois sur la modélisation de ces risques, sur les mesures utilisées pour les quantifier, sur le risque de modèle, sur les techniques d'estimation et aussi sur les problèmes d'optimisation liés à l'atténuation ou au transfert de ces risques. La capacité de réaction rapide étant souvent clé en gestion des risques, les problématiques de détection de changement de tendance ont aussi été abordées, notamment pour les risques de longévité et climatiques. Ces questions sont intéressantes non seulement pour les entreprises, mais aussi pour les chercheurs universitaires qui y trouvent une source de nouveaux défis mathématiques.

Les intervenants provenant de ces différents champs disciplinaires ont pu constater les similitudes et complémentarités de leurs approches respectives. Ainsi l'un des organisateurs (Manuel Morales) a monté un projet intitulé "Nouvelle approche de la théorie de la ruine et application en toxicologie" avec d'autres chercheurs français et canadiens, qui a été déposé auprès du Fonds France-Canada pour la Recherche.

Colloquium
Entretiens Jacques-Cartier
Aventures en physique mathématique

November 19–21, 2012, Lyon 1

Sponsored by the CNRS, the CRM, the Université Lyon 1, the Université de Savoie, the Laboratoire d'Annecy-le-Vieux de Physique Théorique, and the Fédération MSIF

Organizers:

John Harnad (Concordia), Claude Roger (Lyon 1), Paul Sorba (CNRS & LAPTH), Luc Vinet (Montréal)

Speakers:

Marco Bertola (Concordia), Robert Brandenberger (McGill), Simon Caron-Huot (Niels Bohr), Matthias Christandl (ETH Zürich), Sylvie Corteel (CNRS & LIAFA); Luminiţa-Iona Cotîrlă (Babeş-Bolyai), Thierry Dauxois (CNRS & Lab./ phys./ ENS Lyon), James Drummond (CNRS & LAPTH), Bertrand Eynard (CEA/Saclay), Patrick Ferrari (Bonn), Vincent Genest (Montréal), Yves Grandati (Lorraine), Mihail Mintchev (INFN & SNS Pisa), Alexei V. Penskoi (IU Moscow), Yvan Saint-Aubin (Montréal), Vyacheslav Spiridonov (JINR), Herbert Spohn (TU München), Thomas Strobl (Lyon 1), Serge Tabachnikov (Penn State), Laurent Vuillon (Savoie), Oleksiy Zhedanov (Donetsk IPE)

Many of the most important and fruitful mathematical theories originated in physical problems. This relationship is well known but new and spectacular developments have illustrated it during the last twenty years. On the other hand modern physics has always needed mathematical tools and models and must follow the progress of the mathematical sciences. The goals of this conference were to gather mathematicians and physicists around some common themes and essential results, and to tighten the already existing connections between Québec scientists and the scientists in the Rhône-Alpes region. Here is the list of lectures that took place at the conference.

- Solitons: revisiting old questions and recent experiments (T. Dauxois)
- Physical and mathematical aspects of quantum wires (M. Mintchev)
- Instances of supergeometry in mathematical physics (T. Strobl)
- Proof of the BKMP conjecture: relating topological strings to matrix models (B. Eynard)
- Pentagram map, twenty years after (S. Tabachnikov)

- From geometry to inhibitors: the story of protein-protein interfaces viewed under the GEMINI software (L. Vuillon)
- Floquet theory, inflationary cosmology and Anderson localization (R. Brandenberger)
- Eigenvalue distribution of reduced density matrices (M. Christandl)
- Free energy fluctuations for directed polymers at positive temperature (P. Ferrari)
- The principal indecomposable representations of the Temperley–Lieb algebra and their physical applications (Y. Saint-Aubin)
- Combinatorics, orthogonal polynomials and ASEP (S. Corteel)
- Recent progress in scattering amplitudes (J. Drummond)
- Riemann-Hilbert problems: a tool of many uses (M. Bertola)
- Elliptic hypergeometric functions, superconformal indices, and integrable systems (V. Spiridonov)
- The Kardar-Parisi-Zhang equation and its universality class (H. Spohn)
- Classical orthogonal polynomials corresponding to the operators of Dunkl type (O. Zhedanov)
- Yang-Mills models in four dimensions: a new kind of integrable systems (S. Caron-Huot)
- New classes of harmonic univalent functions (L.-I. Cotîrlă)
- The algebra of dual 1-Hahn polynomials and the Clebsch-Gordan problem of the quantum algebra sl(2) at $q = -1$ (V. Genest)
- New rational extensions of solvable potentials with finite bound state spectrum and enlarged shape invariance (Y. Grandati)
- Spectral geometry and mathematical physics joint quest for extremal metrics (A. V. Penskoi)

SUMM 2013
Seminars in Undergraduate Mathematics in Montréal

January 25–27, 2013, UQAM

Sponsored by Concordia University, McGill University, Université de Montréal, Université du Québec à Montréal, STUDC, the CRM, the ISM, Maplesoft, SUMS, MASSA, and the AESS (UQAM)

Organizers:

Jean-François Arbour (UQAM), Geoffroy Bergeron (Montréal), Mathilde Gerbelli-Gauthier (McGill), Léo Belzile (McGill), Kevin Shao (Concordia)

Speakers:

José Garrido (Concordia), Christian Genest (McGill), Christophe Reutenauer (UQAM), Robert Seiringer (McGill), Luc Vinet (Montréal)

Student Speakers:

Jean-François Arbour, Léo Belzile, Younes Ben-Ghabrit (UQAM), Geoffroy Bergeron, Carolyn Campbell (McGill), Simon Chatelain (McGill), Mathilde Gerbelli-Gauthier, Jonathan Godin (Laval), Asad Haris (McGill), Nicole Keating (McGill), Aditya Kumar (McGill), Jean Lagacé (Montréal), Olivier Martin (McGill), Thomas Ng (McGill), Laurent Pelletier (Laval), Michael Snarski (McGill), Matthew Stevenson (McGill), Mashbat Suzuki (McGill)

Number of participants: 97

Depuis maintenant quatre ans, les Séminaires universitaires en mathématiques à Montréal se font un devoir de rassembler les étudiants québécois passionnés par les mathématiques et la statistique dans la métropole. Se faisant, l'organisation les encourage à échanger entre eux et transmettre leur passion pour une branche ou une autre de leur discipline d'étude dans une ambiance décontractée. L'évènement vise donc à promouvoir les mathématiques, favoriser les échanges entre étudiants de premier cycle en mathématiques, créer des liens entre les différentes universités de la métropole et initier la communauté académique de demain au partage des connaissances.

L'édition 2013 aura été marquée par le retour des Séminaires à l'UQAM et le retour des activités du vendredi soir, permettant des rencontres entre étudiants dans un contexte plus convivial. Cette année, les organisateurs se sont fait un devoir de collecter des statistiques sur l'évènement qui serviront d'indicateurs-clés pour la prochaine édition. C'est ainsi que 83 participants, un nombre premier, incluant un groupe de 7 étudiants de Québec, sont venus échanger autour d'exposés étudiants et de quatre conférences plénières, avec un conférencier invité de chaque université et, cette année, une présentation sur les opportunités de financement et sur les groupes de recherche, faite par le directeur de l'ISM, Christian Genest. Chaque année, les conférences plénières constituent une attraction majeure des Séminaires. Nous avons eu l'honneur d'accueillir cette année José Garrido, Luc Vinet, Christophe Reutenauer et Robert Seiringer. L'expertise de ces conférenciers permit aux participants de s'initier à des sujets de pointe en mathématiques; elle favorisa aussi la création

de liens entre la communauté universitaire actuelle et celle de demain.

L'évènement se déroula sans anicroche, et la satisfaction manifeste des participants a fait honneur aux nombreux bénévoles et aux organisateurs. Nous sommes très fiers de la participation étudiante, de l'enthousiasme des conférenciers et de la diversité des présentations étudiantes de cette année. Le bilinguisme de l'évènement, reflétant la réalité de la communauté universitaire montréalaise, a été maintenu, avec notamment l'introduction de diapositives dans la langue complémentaire pour les exposés bilingues. Nous espérons que ces Séminaires sauront former et intéresser les jeunes chercheurs de demain.

Le comité d'organisation tient à remercier les institutions qui lui ont apporté un soutien financier (et qui sont mentionnées ci-dessus). L'équipe tient également à souligner la participation des gens de l'Université Laval, qui ont assisté aux Séminaires grâce au soutien financier du STUDC, le comité étudiant de la Société mathématique du Canada.

2013 Montréal–Toronto Workshop in Number Theory
p-Divisible Groups

April 18–19, 2013, CRM
Sponsored by CICMA

Organizers:
Eyal Z. Goren (McGill), Stephen S. Kudla (Toronto)
Speakers:
Dylan Attwell-Duval (McGill), Francesca Bergamaschi (Milano & Concordia & McGill), Amy Cheung (McGill), Eyal Z. Goren, Andrew Fiori (McGill), Steven S. Kudla, Luiz Takei (McGill), Patrick Walls (Toronto), Ying Zong (Toronto)
Number of participants: 42

The Montreal Toronto workshops in number theory are a joint enterprise of the Centre de recherches mathématiques in Montreal and The Fields Institute in Toronto. The meetings are run twice a year as workshops focused on a particular topic in number theory. One of their main goals is to foster scientific relationships between the Montreal number theory community (including the Université Laval in Québec City and the University of Vermont) and the Toronto number theory community (including McMaster University). The workshops have been very successful instructional events, unique within the scope of the activities of the research institutes. A secondary goal is to allow students to develop skills for making presentations; the background talks at the workshop are given by graduate students and postdocs.

The fifth meeting was devoted to the topic of p-divisible groups or Barsotti-Tate groups. These objects have become an indispensable tool in many areas in arithmetic geometry, for example in the study of Shimura varieties, automorphic representations, Galois representations, and variations of zeta functions. Their usefulness keeps extending into other domains. The workshop attempted to give an overview of the subject, starting from the very first definitions and results (going back 50 years or so) and ending with some of the most current topics of interest, such as Rapoport-Zink spaces and Kisin modules. As with previous meetings, the level of presentations was exceptionally high and the participants indeed were able to get a panoramic view of the subjects, as much as can be done in 10 hours.

As with previous workshops, we have made the content of the talks available to the public. The notes of the present workshop can be found at http://www.math.mcgill.ca/goren/Montreal-Toronto/Montreal-Toronto.5.html. The detailed program was as follows: Dylan Attwell-Duval (Definitions and main examples); Luiz Takei (Witt vectors); Patrick Walls (Dieudonné modules); Andrew Fiori (Classification of p-divisible groups up to isogeny); Ying Zong (Deformations, crystals and Grothendieck-Messing theory); Amy Cheung (The Serre-Tate theorems); Francesca Bergamaschi (Kisin Modules); Steve Kudla (Stratification of unitary Shimura varieties); Eyal Goren (Stratifications of moduli spaces and p-adic uniformization).

Adventures in Superspace

April 19–20, 2013, McGill
Sponsored by the Mathematical Physics Laboratory

Organizers:
Robert Brandenberger (McGill), Jim Gates (Maryland), Martin Rocek (Stony Brook)
Speakers:
Tirthabir Biswas (Loyola), Cliff Burgess (McMaster), Bernard de Wit (Utrecht), Michael Duff (Imperial Coll.), Dan Freedman (MIT), Jim Gates, Renata Kallosh (Stanford), Ulf Lindstrom (Utrecht), Martin Rocek, Warren Siegel (Stony Brook), Kelle Stelle (Imperial

Coll.), Peter van Nieuwenhuizen (Stony Brook), Antoine van Proeyen (KU Leuven)

Number of participants: 20

This workshop was organized to celebrate the contributions of Professor Marcus Grisaru to the field of supergravity. We were happy that all of the senior experts in the field of supergravity who together with Marcus helped create the field accepted our invitation to come to this workshop. In particular, Professors Jim Gates (recently awarded the US National Medal of Science), Martin Rocek, and Warren Siegel participated. Together with Grisaru, the four are authors of the ground-breaking textbook "Superspace, or One thousand and one lessons in supersymmetry." Profs. de Wit, Duff, Freedman, Lindstrom, Mezincescu, Stelle, Townsend, van Nieuwenhuizen and Van Proeyen are all senior experts in the field of supergravity and have all at some point collaborated with Marcus Grisaru. It was a rare treat to have all of these experts in the same place at the same time. Here is a list of some of the talks.

- M. Grisaru & the Eden of Supergravity (J. Gates)
- Gauge multiplets and gauging in D=2 sigma-models (M. Rocek)
- Anomaly multiplets, regrisaruzation & solitons (P. van Nieuwenhuizen)
- 3D strings: an open-and-shut case (P. Townsend)
- Generalized Kähler geometry and sigma models (U. Lindstrom)
- Superconformal symmetry and higher-dimensional Lagrangians (A. van Proeyen)
- A Superspace Odyssey (B. de Wit)
- UV properties of N=8 and N=4 supergravities (R. Kallosh)
- UV divergences in maximal and half-maximal supergravity (K. Stelle)
- The holographic dual of F-maximization (D. Freedman)
- Vanish without a trace (M. Duff)
- Towards consistent nonlocal theories of gravity (T. Biswas)
- Supersymmetric cancellations without superpartners: having your cake and eating it too (C. Burgess)

Spring School
7th Montréal Scientific Computing Days

May 13–15, 2013, CRM

Sponsored by the Applied Mathematics Laboratory

Organizers:

Emmanuel Lorin de la Grandmaison (Carleton), Robert Owens (Montréal)

Invited Speakers:

Xavier Antoine (Lorraine), Michael Griebel (Bonn), Doron Levy (Maryland)

Other Speakers:

Gustavo Avila-Blanco (Queen's), Muhammad Awais (Victoria), Tucker Carrington (Queen's), Alexandre Desfossés Foucault (Montréal), François Fillion-Gourdeau (Montréal), Denis F. Hinz (McGill), Azadeh Jafari (Montréal), Tae-Yeon Kim (McGill), Lahcen Laayouni (Al Akhawayn), David Lapierre (Montréal), Felicia Magpantay (York), Mike McLeod (Ottawa), Maryam Namazi (CCCMA), David Shirokoff (McGill), Ilyssa Summer (Arizona State), Alexandra Tcheng (McGill), Jinming Wen (McGill)

Number of participants: 67

The Montréal Scientific Computing Days (MSCD) is a workshop quite unique in its format in Québec. This meeting covers a wide spectrum of mathematical themes centred around scientific computing: the analysis of partial differential equations, numerical analysis, computational sciences, high performance computing, as well as numerous application areas in physics, biology, medicine, finance, etc. As far as is reasonably possible, the MSCD tries to maintain a good balance between theory and applications. The workshop that took place in May of this year was the seventh in a series that has enjoyed great success in the past, thanks in particular to the high quality of the invited speakers (whose course notes have been made available online to participants) and to the active participation of the graduate students and postdocs. This year 67 people registered for the workshop, and although the great majority of participants came from universities in Québec and Ontario, others came from as far afield as Morocco, Texas, and British Columbia.

The MSCD is an ideal opportunity for students and other researchers from various scientific communities (physicists, mathematicians, computer scientists, etc.) to interact in a welcoming and informal setting. The workshop also gives graduate students and postdocs the opportunity of taking short courses, each of three hours' duration and pitched at an accessible level, and given by researchers of international stature. This year's invited speakers were Xavier Antoine, Michael Griebel, and Doron Levy. Prof. Antoine delivered a series of talks entitled *How to truncate a PDE problem set*

in an unbounded domain: the example of the Schrödinger equation.

The goal of this introductory course was to give an overview of some of the techniques that can be used to truncate the spatial domain on which is defined a partial differential equation in an attempt to minimize the effect of the truncation operation. At the heart of the presentations was a detailed treatment of absorbing boundary condition methods and others for tackling general problems with particular application to the Schrödinger equation. This equation, which has many applications in physics and engineering, leads to difficult questions concerning the mathematical construction of absorbing boundary conditions as well as their numerical approximation. In particular, even in the simplest case, it is necessary to develop nontrivial solutions to get numerical schemes with suitable properties (like stability).

In this course, Prof. Antoine discussed the following questions, of increasing difficulty:

- the free space one-dimensional Schrödinger equation;
- how to take into account potentials in 1d;
- how to extend the methods to 1d nonlinear problems;
- two-dimensional problems; and
- inclusion of potentials and nonlinearities.

Prof. Griebel's mini-course of three lectures was on the theme of generalized sparse grids. Efficient approximations for multivariate functions can be derived from a one-dimensional multilevel representation of a function (hierarchical basis, generating system, (pre)wavelet system, Fourier series, eigenfunction series, or similar methods) by a product construction to obtain a multilevel system for the many-dimensional case and a subsequent proper truncation of the resulting series expansion. This leads to so-called sparse grids, which promise to cope with the curse of dimensionality in conventional product discretizations, at least to some extent. First, Prof. Griebel discussed regular sparse grids and their approximation and cost complexities. Besides regular sparse grids, one can also construct (by means of an optimization process) specific problem-dependent sparse grids that exhibit optimal asymptotic complexity estimates for various situations, error norms, and regularity assumptions. Prof. Griebel presented such methods in detail and, in conclusion, discussed various applications.

In recent years, mathematical models have been playing an increasing role in cancer studies. The underlying complexity of the biological processes requires researchers to use mathematical models of different types, including discrete and continuous models, deterministic and stochastic models, and models with time delays. The lectures by Prof. Doron Levy were on numerical methods for mathematical models of cancer dynamics and on agent-based models (ABM) in cancer. In the former topic, we learned about numerical methods for delayed differential equations and numerical methods for nonlinear time-dependent PDEs. In the latter topic, Prof. Levy discussed ABMs for solid tumor growth and the Roeder model of stem cells. He went on to explain how to pass from ABMs to PDEs and concluded his series of talks with a presentation of related techniques, including crime models and a technique for deriving various Fokker-Planck equations from stochastically interacting particles. The detailed slides of the mini-courses given by the three invited speakers may be downloaded from http://www.crm.umontreal.ca/Comp13/diapo_e.shtml.

As well as being an opportunity for graduate students and post-docs to keep abreast (through the mini-courses) of some of the latest research directions in computational applied mathematics, the MSCD also affords a unique opportunity for these students to make an oral presentation on the results of their research, both to their own peer group and to the wider applied mathematics community in Québec. In all 16 such presentations were given during the workshop, and in keeping with tradition, it was expected that a prize (in the form of a SIAM book token) would be awarded for the best presentation. The overall standard of student and postdoc talks, however, was very high and the choice of the most deserving candidate was exceptionally difficult. The scientific committee (composed of Yves Bourgault, from the University of Ottawa, Emmanuel Lorin de la Grandmaison, and Robert G. Owens) decided that the prize should be awarded *ex aequo* to Alexandre Desfossés Foucault, Felicia Magpantay, and Alexandra Tcheng. These three are warmly congratulated on the excellence of their research and the clarity and impact of their presentations.

Workshop
$\mathcal{N} = 2$ Jeometry and ApplicationZ Part II

May 22–24, 2013, McGill

Organizers:
Keshav Dasgupta (McGill), Jihye Seo (McGill), Johannes Walcher (McGill)
Speakers:
Richard Eager (Kavli Inst.), John Harnad (Concordia), Simeon Hellerman (Kavli Inst.), Jacques Hurtubise (McGill), Kazunobu Maruyoshi (Caltech), Domenico Orlando (CERN), Chan Youn Park (Caltech), Jaewon Song (UC San Diego), Masahito Yamazaki (Princeton)
Number of participants: 33

This workshop was a second installment of $\mathcal{N} = 2$ Jeometry and ApplicationZ. Last year's participants, Kenneth Intriligator (UC San Diego) and Nathan Seiberg (IAS), acknowledged the first installment in their preprint "Aspects of 3d N = 2 Chern-Simons-Matter Theories," which appeared this May on arxiv, as arXiv:1305.1633. It was also mentioned in the New York Times. This year's focus was more mathematical, featuring superconformal index counting, Vasiliev's theories, superconnection constraint equations, Chern-Simons theory, Sasaki-Einstein, lens space, and topological string.

The theme of the workshop was 4-dimensional supersymmetric field theories. There have been lots of interest and progress recently in this area. Most pioneering works are a new set of theories called "class S," which is obtained by wrapping M5 branes on a Riemann surface, by Gaiotto-Moore-Neitzke and Alday-Gaiotto-Tachikawa correspondence relating a certain class of 4-dimensional $\mathcal{N} = 2$ superconformal theories to 2-dimensional (bosonic) conformal theories, and "Nekrasov-Shatashvili" relation between Ω-deformed $\mathcal{N} = 2$ theories and quantum integrable systems.

Equipped with cluster coordinates and bipartite networks, studies of $\mathcal{N} = 2$ theories are gaining even larger momentum these days, signaling potential relevance to brane tilings in $\mathcal{N} = 1$ quiver and scattering amplitudes of $\mathcal{N} = 4$ super Yang-Mills theory. These are pioneered by Xie, Franco, Yamazaki, Cachazo, Arkani-Hamed et al. A close relationship between supersymmetric field theories and totally non-negative Grassmannians is studied with varying amount of supersymmetry $1 \leq \mathcal{N} \leq 8$.

The workshop also included supersymmetric field theories in other dimensions, and with different amounts of supersymmetry. There were many discussions of string compactification, Vasiliev theory, AdS/CFT, S-dualities, Wilson loops, etc. The organizers provided an interface for interactions between the math and physics communities. There were two math review talks by local researchers and eight physics talks from external speakers.

According to Chan Youn Park, M2 branes between two M5 branes wrapping a Seiberg-Witten curve are described by a 2d $\mathcal{N} = (2, 2)$ Landau Ginzburg model with chiral fields and superpotential. He discussed how to construct spectral networks to analyze the BPS spectra and their wall-crossing in his talk "Spectral network and BPS spectrum of SCFT." He studied examples of spectral networks to illustrate how to utilize the results in identifying SCFTs that have different descriptions. He performed a similar analysis and computed central charges and gauge/flavour charges for the Argyres-Douglas theory, an interacting SCFT theory with 4d and N=2 with mutually nonlocal massless states.

The T_N theory is a $\mathcal{N} = 2$ SCFT theory obtained by compactifying a 6d (2,0) theory of M5 branes on a sphere with three full punctures with $SU(N)^3$ flavour symmetry, with no Lagrangian description. Kazunobu Maruyoshi gave a talk entitled "$\mathcal{N} = 1$ Dynamics with T_N superconformal field theories," in which he explained the coupling of T_N's to $\mathcal{N} = 1$ vector multiplets. By reducing Csaki–Schmaltz–Skiba–Terning duality, he and his collaborators obtain a duality between conventional theory (such as supersymmetric QCD) and non-conventional theory. He showed that the theory exhibits confinement, superconformal, and Abelian Coulomb phases, depending on the manner of coupling T_N theories to $\mathcal{N} = 1$ vector multiplets. In particular, a $\mathcal{N} = 1$ $SU(N)$ gauge theory coupled to two T_N theories, which flows to a superconformal fixed point, has dual descriptions with gauge singlet fields, and this leads to, by Higgsing, a new duality of $\mathcal{N} = 1$ SQCD with $N_f = 2N$.

Masahito Yamazaki and Richard Eager discussed index computation, to test S-duality and AdS/CFT correspondence. Although the Lagrangian description is often used in Feynman diagrams in QFT, it is not fundamental (as seen from recent works by Freddy Cachazo and Nima Arkani-Hamed). Gauge symmetry is also not fundamental: it is considered to be a redundancy and it can even change under Seiberg duality. In Yamazaki's talk "4d $\mathcal{N} = 2$ Lens indices from S-duality," he asks whether (Gaiotto-like) S-duality is fundamental to QFT. "Is S-duality powerful enough to characterize a theory completely?" might be too ambitious a question and ambiguous. So he tries to answer

the following question: "Is S-duality powerful enough to characterize the lens space index completely?" He finds that the lens index, which is a partition function computed on $S^1 \times S^3/\mathbb{Z}_r$, is almost completely determined by S-duality and that S-duality is indeed powerful.

The superconformal index is the partition function of the $(1+d)$-dimensional superconformal field theory on $S^1 \times S^d$ with supersymmetric boundary conditions. It is also the generating function of the number of operators weighted by their fermion number. The index is independent of the exact marginal deformations of the theory, and is calculable if the UV Lagrangian is known. In a talk titled "Superconformal indices in dimensions 2, 3, and 4," Eager considered the gauge theory index, the gravity index, and the elliptic genus in order to check the AdS/CFT correspondence. He computed the superconformal index of M2 branes probing the cone over an arbitrary Sasaki–Einstein sevenmanifold and that of a D3 brane probing the Calabi–Yau cone. The index should be invariant under Seiberg duality and AdS/CFT. His talk also led to a discussion about the spectrum of Sasaki–Einstein manifolds and solving Heun's equation. The second-order equation reduces to a linear equation for the BPS spectrum. There were questions about the choice of contour.

We had two talks related to the Nekrasov's partition function and the Ω deformation. The Ω background was introduced by Nekrasov to regularize the 4d instanton partition function and reproduce the results of Seiberg-Witten. The Ω deformation is controlled by two parameters $\varepsilon_{1,2}$ and various interesting limits exist, such as topological string on Calabi–Yau, Samson's limit (quantum integrable model), refined topological string, and AGT.

Domenico Orlando talked about how the Ω deformation can be understood from the viewpoint of old-fashioned string theory, based on Neveu-Schwarz fields. His talk was entitled "the Ω deformation from string and M-theory." It allowed one to understand localization in geometric terms. The Ω deformation is an effective 4d action for the fluctuations of the M5-branes. The parameter $\varepsilon_{1,2}$ appears as a noncommutativity parameter in the quantum spectral curve, and there appears a Riemann surface embedded in a non-commutative complex plane.

In a talk entitled "The ABCDEFG of 4d/2d Correspondence," Jaewon Song explained how to obtain the BCFG group (in 2d and 4d theories) from ADE (in 6d theory). In simple language, folded Lie algebras can be obtained by various foldings as a 6d theory is compactified onto 2d and 4d theories. This work was inspired by Rastelli et al's work on the correspondence between 4d index and 2d TQFT. There were many discussions about the scheme-dependence of the Nekrasov partition function.

There were two talks related to the Chern-Simons theory. Masahito Yamazaki talked about "3d Chern-Simons from M5-branes." He discussed 3d theories coming from the 6d theory of M5 branes. He discussed the partition function of 5d $\mathcal{N} = 2$ SYM, which is the dimensional reduction of the 6d theory. By supersymmetric localization the 5d partition function reduces to that of the 3d pure Chern-Simons theory. This work had two goals: one is to improve the conceptual understanding of AGT (Alday-Gaiotto-Tachikawa), which is a 4d-2d correspondence, and the other is to formulate a 3d-3d equivalence of AGT. There were many discussions about the role of the $U(1)$ orbit inside the 6d internal geometry as we compactify the 6d theory into a 5d SYM theory.

The talk "Chern-Simons-Matter Theory and its Holographic Dual" (by Simeon Hellerman) was about debunking many myths around Vasiliev theory. In his invigorating talk, he emphasized the beauty of $\mathcal{N} = 4$ SYM and left a famous quote: that physics textbooks must discuss $\mathcal{N} = 4$ SYM before they discuss Maxwell's theory of electromagnetism. The biggest problem with Vasiliev theory and the proposal for its AdS/CFT dual comes from the counting of degrees of freedom. Hellerman emphasized that Vasiliev theory does not have a consistent ultraviolet completion, and de Sitter / CFT is not viable in its current form. It was very alarming and insightful in many ways. He mentioned his work in progress on branes in topological string theory, and there were many questions about gravitons built out of open strings, and the possibility of addressing the higher-genus case (beyond S^3). Hellerman led an afternoon discussion session and the upshot was that the Chern-Simons theory has no local degrees of freedom and the correction to the spectrum, if not zero, is very small (exponentially suppressed).

In order to foster more interaction between mathematicians and physicists, the workshop included 2 other mathematical talks. The results have significance for many recent works in the physics literature on superspace null polygonal Wilson loops in supersym-

metric Yang-Mills theories. In recent computations of super null polygonal Wilson loop amplitudes in superspace by Beisert, He, Vergu, et al, an essential ingredient is the super null line constraint equations, which provide the necessary conditions for the "thickened null line" integrations to be well defined.

Jacques Hurtubise gave a talk entitled "The geometry of supersymmetric Yang-Mills in four dimensions," about his work with John Harnad and Steve Shnider on superconnection constraint equations. Hurtubise presented the $d = 4$ results connecting the constraint equations and the field equations for $\mathcal{N} = 0, 1, 2, 3$. Another talk was given by John Harnad, under the title of "Constraints and field equations for $d = 10, \mathcal{N} = 1$ SYM," presenting the analogous results for $d = 10$, $\mathcal{N} = 1$, which (by dimensional reduction) also give a simpler derivation of the $d = 6, \mathcal{N} = 2$ and $d = 4$, $\mathcal{N} = 4$ cases, with a summary of how the twistor correspondences extend to arbitrary dimensions. Harnad reviewed the equivalence between the constraint equations and the field equations in the $d = 10, \mathcal{N} = 1$ SYM theory, underlying Witten's "super-twistor-like transform" and the dimensional reduction procedure that implies the corresponding results for $d = 6, \mathcal{N} = 2$ and $d = 4, \mathcal{N} = 4$.

The workshop was hosted by the McGill physics department and had the same format as other successful events organized by McGill's Center for High-Energy Physics about three to four times a year: Two and a half days with several external speakers in a relaxed atmosphere with ample time for discussions. Such a format is of particular benefit for graduate students around Montréal, who have the opportunity to meet and interact with distinguished scholars in their chosen field of study. Everyone left Montréal looking forward to a future meeting. This year's participants were of the opinion that our workshop was really lovely, *extremely* stimulating, and informative.

GAP 2013: Geometry And Physics

May 30–June 1st, 2013, CRM
Sponsored by the Perimeter Institute for Theoretical Physics, the University of Waterloo Faculty of Mathematics, the CRM, and the McMaster University Faculty of Science

Organizers:
Marco Gualtieri (Toronto), Spiro Karigiannis (Waterloo), Ruxandra Moraru (Waterloo), Johannes Walcher (McGill), McKenzie Wang (McMaster)

Speakers:
Philip Boalch (CNRS; ÉNS), Sergey Cherkis (Arizona), Tamàs Hausel (EPFL), Andrew Neitzke (UT Austin), Lauren Williams (UC Berkeley)

Number of participants: 62

GAP 2013 consisted of five minicourses, each three hours long, given by Philip Boalch, Sergey Cherkis, Tamás Hausel, Andy Neitzke, and Lauren Williams, to a mixed audience consisting of graduate students, postdoctoral researchers, and senior researchers. The longer format meant that speakers could go into greater depth and cover more of the field than would have otherwise been possible. The common focus topic, that of wall crossing phenomena in moduli spaces, also meant that the audience could focus for an extended period of time on a smaller number of concepts and their interrelations. The most remarkable outcomes of the workshop format were emergent relationships between the talks that even the speakers had not intended. On many occasions, heated discussions erupted during the talks between various experts among the speakers and the audience about possible extensions and applications of the presented results. Indeed, what began as a pedagogical exercise rapidly became a real-time research workshop.

Philip Boalch used his lectures as an opportunity to describe an important family of moduli spaces that has occupied his research for many years: the wild character varieties. These are moduli spaces of meromorphic connections on Riemann surfaces, but with irregular singularities. The study of irregular singularities and their associated Stokes phenomena have traditionally been viewed as highly technical and abstruse, but through his recent work Boalch has clarified, generalized, and significantly extended the theory, exposing its beauty as well as its many applications in mathematical physics. In addition to surveying the structure theory of these spaces, Boalch explained the appearance of these moduli spaces in several important areas including quantum groups.

Tamás Hausel's minicourse focused on his recent remarkable computations and conjectures concerning the Betti numbers of the character varieties that are diffeomorphic to the moduli space of Higgs bundles. These computations were made by expressing the character varieties as algebraic varieties over finite fields and then counting rational points using character formulas for representations of finite groups of Lie type. His results are the culmination of many years

of research into the topology of Higgs moduli spaces, and he was able to describe very clearly the train of thought leading from Hitchin's original work directly to his recent papers, as well as the work of Ngo on the fundamental lemma.

Sergey Cherkis, in only three lectures, was able to describe the vast subject of gravitational instantons, covering ALE, ALF, ALG, and ALH spaces, and their beautiful explicit constructions as moduli spaces. He described in a unified manner the various tools which are used in this story, starting with the ADHM construction, Nahm's equations, and the Nahm transform, among others. There was also an introduction to twistor theory, toric geometry, and even tropical geometry. Cherkis' lecture series was particularly inspiring to the graduate students in attendance, who may have learned many of the techniques mentioned in his course, but not seen how they are applied to solve deep problems in mathematical physics.

Andy Neitzke used the opportunity given him by the triple of lectures to describe his body of work with Gaiotto and Moore on Spectral Networks in a completely novel way: rather than focusing on the use of spectral networks for possibly determining the Hyper-Kähler metric on the moduli space of Higgs bundles, Neitzke focused instead on the potential for finding explicit solutions to Hitchin's equations. This approach provided a much more direct and less front-loaded approach to his recent papers, and was particularly inspiring to the many people in the audience who study Stokes phenomena and irregular singularities. His lectures were also remarkable in the number of open mathematical questions that were posed: the exciting prospect of developing these offshoots, especially the connection to Lauren Williams' talks on cluster algebras, motivated many questions from the audience.

Lauren Williams presented what is perhaps the clearest and most straightforward description of cluster algebras yet. Starting with startlingly simple combinatorial setups, she quickly layered these together to obtain a description of the cluster structure on Grassmannians, describing all the major features of the theory of cluster algebras along the way, including the relation to bordered surfaces, triangulations, ADE quivers, and mutations, among many others. The connections between the various topics touched upon by Williams and the other talks were surprising to many, including to the other speakers.

In conclusion, the new format of the GAP 2013 conference at the CRM was a surprisingly effective one, not only for student researchers attempting to enter the field, but also for the senior researchers present, who may not always glean, from the published papers, as many insights as one does when the experts themselves are teaching their subject.

Colloquium and Seminar Series

The CRM, together with the Institut des sciences mathématiques (the Québec universities graduate mathematics consortium), runs two Montréal colloquium series, one in mathematics and the other in statistics (the latter jointly with GERAD, an operations research centre located in the André-Aisenstadt building). During the academic year, these series offer survey talks on topics of current interest by distinguished mathematicians and statisticians.

CRM–ISM Mathematics Colloquium

In 2012–2013 the colloquium coordinators were Iosif Polterovich (Montréal) and Mikaël Pichot (McGill).

September 14, 2012
Robert McCann (Toronto)
A glimpse at the differential topology and geometry of optimal transportation

September 21, 2012
Walter Neumann (Columbia)
Geometry of complex surface singularities

October 12, 2012
Rupert Frank (Princeton & Caltech)
Symmetry and reflection positivity

November 2, 2012
Jürg Fröhlich (ETH Zürich)
Dissipative motion from a Hamiltonian point of view

November 16, 2012
Konstantina Trivisa (Maryland)
On the Doi model for the suspension of rod-like molecules & related equations

November 23, 2012
Alexander Gamburd (Graduate Ctr., CUNY)
Expander graphs, thin groups, and superstrong approximation

December 7, 2012
Yuri Tschinkel (NYU & Simons Found.)
Igusa integrals

January 25, 2013
Sheila Sandon (CNRS; Nantes)
Global rigidity in contact topology

February 1, 2013
Elliott Lieb (Princeton)
Proof of a 35-year-old conjecture for the entropy of $\mathrm{SU}(2)$ *coherent states, and its generalization*

February 8, 2013
Sergei Tabachnikov (Penn State)
Pentagram map, twenty years after

February 15, 2013
Nilima Nigam (Simon Fraser)
Eigenproblems, numerical approximation and proof

March 1, 2013
Frithjof Lutscher (Ottawa)
Mathematical models for river ecosystems

March 28, 2013
Victor Guillemin (MIT)
Moser averaging

April 5, 2013
Ehud DeShalit (Hebrew)
Integral structures in p*-adic representations*

April 12, 2013
Narutaka Ozawa (Kyoto)
Quantum correlations and Tsirelson's problem

CRM–ISM–GERAD Statistics Colloquium

In 2012–2013 the organizing team of the Statistics Colloquium included Mylène Bédard (Montréal), Simon Guillotte (UQAM), Abbas Khalili (McGill), Lea Popovic (Concordia), and David A. Stephens (Concordia).

September 21, 2012
Fang Yao (Toronto)
Regularized semiparametric functional linear regression

October 19, 2012
David Madigan (Columbia)
Observational studies in healthcare: are they any good?

November 23, 2012
Peter Müller (UT Austin)
A nonparametric Bayesian model for local clustering

December 14, 2012
Raymond J. Carroll (Texas A&M)
What Percentage of children in the U.S. are eating a healthy diet ? A statistical approach

January 18, 2013
Victor Chernozhukov (MIT)
Inference on treatment effects after selection amongst high-dimensional controls

March 22, 2013
Hélène Massam (York)
The hyper Dirichlet revisited: a characterization

April 12, 2013
Arup Bose (ISI Kolkota)
Consistency of large dimensional sample covariance matrix under weak dependence

Multidisciplinary and Industrial Program

The main vehicles for the CRM's efforts in this area are the research networks to which it belongs, principally Mprime, a national network focusing on the mathematics of information technology and complex systems. *The reports are presented in the language in which they were submitted.*

Activities of the Multidisciplinary and Industrial Program

6th International Conference on Information Theoretic Security (ICITS)

August 15–17, 2012, Montréal

Sponsored by the CRM, the Institute for Quantum Computing (University of Waterloo), and INTRIQ (a strategic cluster funded by the FRQNT)

Organizers:

Jürg Wullschleger (Montréal), Alain Tapp (Montréal), Claude Crépeau (McGill), Adam D. Smith (Penn State), Olivier Coutu (Montréal)

Number of participants: 58

The International Conference on Information Theoretic Security (ICITS) is a conference about all aspects of information-theoretic security. Its aim is to bring together researchers from all over the world from the areas of cryptography, information theory and quantum information. The conference was created as a successor of the "IEEE Information Theory Workshop on Theory and Practice in Information-Theoretic Security" on Awaji Island, Japan, and takes place every 18 months, alternating between Asia, Europe and North America. Previous ICITS conferences were held in Madrid (Spain), Calgary (Canada), Shizuoka (Japan), and Amsterdam (The Netherlands). ICITS 2012 was held from August 15 to 17, 2012 in Montréal.

As in previous ICITS conferences, the plenary talks were given by the leading researchers in the field. One of the highlights of this conference was the talk by Salil Vadhan from Harvard University, who gave a presentation about "The Many Entropies of One-Way Functions." The other plenary talks were given by Serge Fehr (CWI Amsterdam), Patrick Hayden (McGill University), Negar Kiyavash (University of Illinois at Urbana-Champaign), Xin Li (University of Washington) and Krzysztof Pietrzak (IST Austria).

The usual process for conferences in Computer Science is that all submitted papers first undergo a careful reviewing process, and all papers that are accepted are not only presented at the conference, but also appear in the conference's proceedings. Previous ICITS conferences also used this format, but it turned out not to be optimal for information theorists and physicists. For this ICITS, the organizers therefore decided to make a special "workshop track," in addition to the more standard "conference track," where the speakers needed to submit only a one-page abstract that will appear in the proceedings. This new format (with both a conference track and a workshop track) was a big success, both in quality and quantity, and having an additional track also increased the number of participants.

Montréal Spring School of Population Genomics and Genetic Edidemiology

May 27–31, 2013, Collège Jean-de-Brébeuf

Sponsored by Génome Québec, the CHU Sainte-Justine Research Centre, the CRM, the Université de Montréal, and McGill University

Organizers:

Luis Barreiro (Montréal), Gillian Greig, Aurélie Labbe (McGill), Damian Labuda (Montréal), Jean-François Lefebvre

Scientific Committee:

Jamie Engert (McGill), France Gagnon (Toronto), Maja Krajinovic (Montréal), Marie-Hélène Roy-Gagnon (Montréal), Julian Little (Ottawa), Erwin Schurr (McGill), Terry Lynn Young (Memorial)

Speakers:

Anna Di Rienzo (Chicago), Youssef Idaghdour (Montréal), Joseph Pickrell (Harvard), Hélène Vézina (UQAC), Ma'n H. Zawati (McGill)

Instructors:

Alexandre Alcaïs (Paris Descartes), Will Astle (McGill), Luis Barreiro, Guillaume Bourque (McGill), Laurent Excoffier (Bern), Celia Greenwood (McGill), Nicolas Lartillot (Montréal), Guillaume Lettre (Montréal), Lluís Quintana-Murci (Inst. Pasteur), Joseph Pickrell

Number of participants: 63

The objective of the School was to provide training in rapidly developing disciplines that are becoming increasingly important in health sciences, such as statistical genetics, human evolutionary genetics, population genomics and bioinformatics. The training was based on real-data examples from the research of the

instructors' laboratories. In one module we also presented genealogical resources specific to Québec.

The school consisted of five days of lectures and computer labs. Days 1 and 2 covered introductory concepts in human population, medical genomics, and genetic epidemiology. Days 3 to 5 consisted of concurrent sessions in advanced concepts in population genomics/statistical genetics and in genetic epidemiology. Before attending the school, participants were invited to review basic concepts in genetics, epidemiology, biostatistics and R-programming, by studying introductory courses from previous years that are posted on our web site.

For the 6th edition of the Montréal spring school, there were 47 participants (28 from Québec, 8 from Ontario, 5 from the USA, 3 from Europe, and 3 from South America) and 15 faculty members from Québec, France, Switzerland, and the USA. The school was a great success this year. Participants really enjoyed the broad scope of the workshop and found that it provided great networking opportunities. The practical computer component was also greatly appreciated.

CRM Prizes

The CRM created and administers, either alone or jointly, four of the eight major national prizes in the mathematical sciences, namely: the CRM–Fields–PIMS Prize, the Prize for Theoretical Physics awarded in collaboration with the Canadian Association of Physicists (CAP), the Prize for young researchers in Statistics awarded jointly with the Statistical Society of Canada (SSC), and the CRM André-Aisenstadt Prize awarded to rising young Canadian stars, selected by the International Scientific Advisory Committee of the CRM. The CRM has invested enormously in time, effort and in its own resources, to propel leading Canadian scientists into the spotlight, giving them international recognition when they most need it.

CRM–Fields–PIMS Prize 2013 Awarded to Bruce Reed

Bruce Reed

Bruce Reed received his degrees in Mathematics and in Computer Science at McGill University. Following postdoctoral fellowships and faculty positions in Europe, Canada, and the USA, he joined the faculty of McGill University in 2001: he currently holds the Canada Research Chair in Graph Theory and was elected as a Fellow of the Royal Society of Canada in 2009.

Bruce Reed has played a leading role in a broad range of research areas in discrete mathematics and theoretical computer science. He is best known for his work on areas within graph theory, with many of his most important contributions being in random structures, graph minors, and graph colouring. The 2013 CRM–Fields–PIMS Prize recognizes his profound contributions to difficult and important problems in the areas of graph minors, graph colouring, algorithmic graph theory, random graphs, and the probabilistic analysis of algorithms. The reader will find a detailed description of Professor Reed's contributions in the Spring 2013 edition of the Bulletin du CRM.

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), and Stevo Todorcevic (2012).

André-Aisenstadt Prize 2013 Awarded to Spyros Alexakis

Dr. Alexakis obtained a B.A. degree from the University of Athens in 1999 and a Ph.D. from Princeton University, under the supervision of Charles Fefferman, in 2005. He held a Clay Research Fellowship as well as a Sloan Fellowship, and has been at the University of Toronto since 2008. Working in the areas of analysis and mathematical physics, alone and with collaborators, he has obtained striking results in at least three different directions. His main contribution, published as a research monograph in the prestigious Annals of Mathematics Studies of Princeton University, is a solution to a conjecture of Deser and Schwimmer regarding the structure of global conformal invariants. Secondly, together with Klainerman and Ionescu, he made important progress in the understanding of the Kerr solutions to Einstein's equations. Finally, jointly with

Spyros Alexakis

Mazzeo, he obtained deep results concerning minimal surfaces with bounded Wilmore energy. This impressive research is described by Dr. Alexakis himself in the Fall 2013 edition of the Bulletin du CRM.

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 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), and Young-Heon Kim (2012).

The CRM–SSC Prize 2013 Awarded to Derek Bingham

Derek Bingham

Derek Bingham obtained a B.Sc. in Applied Mathematics at Concordia University in 1991. After several co-op jobs that were entirely statistical in nature, he decided to pursue an M.Sc. in Statistics at Carleton University where he received the Senate Medal in 1994 for his thesis work. Derek also worked full-time at Andersen Consulting from 1993 to 1995. He moved out west in 1995 to pursue his Ph.D. studies at Simon Fraser University (SFU) under the supervision of Randy Sitter. He received his Ph.D. from the Department of Mathematics and Statistics at SFU in 1999, winning the Governor General's Gold Medal. After graduation he joined the Department of Statistics at the University of Michigan as an Assistant Professor. In 2003 he moved back to SFU as the Canada Research Chair (Tier II) in Industrial Statistics in the Department of Statistics and Actuarial Science.

D. Bingham's research interests lie in the design and analysis of experiments in the physical and engineering sciences. He has made contributions in the development of statistical methodology for the design and analysis of experiments on complex computer simulators, fractional factorial designs for multi-stage experiments, and optimal robust parameter designs for product variation reduction. Much of his research has been motivated through scientific collaborations. For example, his work on fractional factorial split-plot designs arose from interactions with scientists in the forest industry. Recent work on computer experiments and uncertainty quantification is the direct result of collaboration with scientists at the Los Alamos National Laboratory, the US National Center for Atmospheric Research, and the Center for Radiative Shock Hydrodynamics at the University of Michigan. A common theme in this work is the development of a framework for assessing the uncertainty in predictions made from mathematical or computer models of physical processes.

During his career, D. Bingham has published over forty papers in peer-reviewed journals and other refereed contributions. His work has appeared regularly in top-tier journals on statistics and experimental design, including the Annals of Statistics, the Journal of the American Statistical Association, Biometrika, and Technometrics. He co-authored a paper on variable selection in computer experiments that won the 2006 Jack Youden Prize for best expository paper published in Technometrics. He has also published many papers in high-impact scientific and engineering journals focusing on the application of statistical design methods. His role in the statistics community (at the Canadian and international level) is important: he is Associate Editor for several journals and he is involved in research councils and SSC activities, in particular by being a member of the Development Committee for the Canadian Statistical Institute.

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, jointly sponsored by the SSC and the CRM, 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.

Derek Bingham is the fifteenth recipient of the CRM–SSC Prize. The previous winners of the award 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), and Changbao Wu (2012).

The CRM Outreach Program

In 2012–2013 several public lectures geared towards a broad audience took place at the CRM. Their format was the same as the format of the *Grandes Conférences du CRM*, which feature outstanding lecturers able to convey the beauty and power of mathematical research to a wide audience. The first two lectures below were part of a CRM program of lectures on the theme "Mathematics of Planet Earth 2013"; the third and fourth lectures were part of the Cross-Canada Series of Lectures on the same theme. The fifth lecture was part of the *Grandes Conférences* series.

In 2012–2013, the *Grandes Conférences* program was under the stewardship of Christiane Rousseau and Yvan Saint-Aubin, professors at the Département de mathématiques et de statistique of the Université de Montréal.

Mathematics of Planet Earth 2013 — CRM Public Lectures

Mathematicians Listen as the Earth Rumbles
Ingrid Daubechies (Duke University)
by Christiane Rousseau (Université de Montréal)

Ingrid Daubechies

On April 10, 2013, Ingrid Daubechies delivered the fourth MPE (Mathematics of Planet Earth) lecture in the Simons Lecture Series. At least 400 persons attended her lecture at the *Coeur des sciences* (Université du Québec à Montréal). Ingrid Daubechies gave her splendid lecture in French and dubbed it herself in English (in front of an empty classroom!). French and English videos are available at the site http://www.videocrm.ca/.

Many people associate *Mathematics of Planet Earth* 2013 with issues related to climate change and sustainable development. The lecture by Ingrid Daubechies, however, fell under the first MPE theme, "A planet to discover." In it Daubechies described her collaboration with geophysicists and their very recent results concerning the formation of isolated volcanic islands. On the floor of the oceans, the most recent rocks are found along the ridges where tectonic plates diverge. The volcanic activity along those ridges pushes magma from the mantle upwards, and this magma is transformed into new rocks. There exist, however, isolated volcanic islands such as Hawaii, Tahiti, the Azores, Cape Verde, etc. In the Hawaii archipelago, the islands are aligned in order of decreasing age, with the largest (and most recent) island being the easternmost island. This observation led geophysicists to conjecture that these islands arose from a volcanic plume, that is, a sort of volcanic chimney through the mantle.

Recall that the mantle depth is approximately equal to half the radius of the Earth. The shifting of the surface tectonic plate might explain the successive formation of islands that are aligned, and the age differences between the islands could be computed by using the distances between them and the speed of the tectonic plate. Further proof is needed, however, in order for the scientific community to acknowledge that this conjecture is true. One way of proving the conjecture would be to "see" the plume. Remote sensing is a tool for exploring the interior of the Earth: one sends signals towards the interior and analyzes the reflected or refracted signals on the various layers of the Earth. This technique is used when looking for oil deposits. The plumes are so far below the Earth's crust, however, that man-made signals are not powerful enough for conducting a remote sensing analysis. The only signals that allow a detailed analysis at such depths are the seismic waves generated by large earthquakes. Ingrid Daubechies and her team had access to large data banks that contain the recordings of seismic waves (as captured by various stations across the globe).

Since the data are available, all that is required is a good tool for analyzing them. The problem is not trivial. The plumes are very thin and the perturbation of a seismic wave speed going through a plume is of the order of 1%. Two seismologists, Tony Dahlen and Guust Noleta, contacted Ingrid Daubechies in 2005 to determine whether wavelets could help them solve this problem. Indeed, Raffaella Montelli's promising results had shown that the analysis of seismic waves allowed

one to detect perturbation zones for pressure waves (P-waves) associated with earthquakes. Such zones had been identified and there was an exact correspondence between them and some isolated volcanic islands; the temperature of the ocean floor was higher in these zones. Because plumes are very thin and the perturbation of the P-waves speed is small, there is a high risk of making an error when reconstructing the Earth's internal structure, unless one makes use of high-performance tools. In this regard wavelets are the perfect tool for analyzing local details in small regions. Moreover wavelet analysis allows one to concentrate on those small regions and disregard the other regions.

During her lecture, Ingrid Daubechies gave a minicourse on wavelet analysis as it is applied to digital images. By grayscale digital image we mean a matrix of numbers including, for each pixel, the "gray intensity" of that pixel. This matrix is used to build four smaller matrices. The first of these contains the horizontal and vertical means of pixel pairs (where the pixels in a pair are neighbours); the second matrix contains the horizontal means and vertical differences of pixel pairs; the third matrix contains the vertical means and horizontal differences of pixel pairs; and the fourth matrix contains the horizontal and vertical differences of the pixel pairs. This process (i.e., the replacement of a matrix by four smaller matrices) is repeated on the first matrix. So far no information has been lost.

Ingrid Daubechies explained how wavelets allow one to compress information and how details in a small region can be extracted (in spite of the fact that much information has been compressed). The use of wavelets in image reconstruction prevents errors in numerical reconstruction and ensures that the singular regions identified within the image are indeed special. Ingrid Daubechies displayed "clean" images produced by wavelet analysis (i.e., images from which artificial regions have been removed). She was able to announce ("hot off the press") that her collaborators and herself had obtained the first results for the whole Earth with real data! The public was delighted by her lecture and asked many questions.

Königsberg's Bridges, Holland's Dikes, and the Fall of Wall Street
Paul Embrechts (École Polytechnique Fédérale de Lausanne)

by Christian Genest and Johanna G. Nešlehová (McGill University)

Paul Embrechts

The *Grandes Conférences du CRM* always attract many people, even when they take place on a Friday night. Furthermore, on May 10, 2013, the lecture was taking place within the 8th edition of the "24 heures de science", which attracted a large audience. This audience was wondering what relations existed between "Königsberg's bridges, Holland's dikes, and the fall of Wall Street" (the topics mentioned in the title of Paul Embrechts' lecture). Paul Embrechts specializes in the theory of extreme values and quantitative risk management. He has written several influential books and more than 150 articles on these research topics. Financial institutions and international regulatory bodies frequently ask him for advice. In his lecture he wished to illustrate (in simple and concrete terms) the contribution of mathematics to the design of protective measures against epidemics, floods, financial crises, and other catastrophes of this nature. The contribution of mathematics lies in the thorough examination of risk factors, the estimation of the probability of exceeding critical levels, and the study of contagion and risk propagation in banking and social networks.

The lecture began with the famous problem of the seven bridges in the town of Königsberg: is it possible to go around the city while crossing each bridge one time and one time only? Euler proved that it is not possible and gave a simple and general technique to solve the problem, for any number of bridges and any bridge configuration. Euler's solution marked the beginning of graph theory. In his lecture Paul Embrechts demonstrated the use of graph theory for modelling the complex interdependence network between financial institutions and evaluating the risk of a bankruptcy bringing about the collapse of the world's financial system (because of cross-undertakings). Basing himself on

results published in *Nature* in August 2012, he also explained how statistical and graphical tools have been used to evaluate the increase in the systemic risk during the mortgage loans crisis, when the risk of a single default triggering a domino effect was very high.

On a conceptual level, the protection of banks against default risks is similar to the defense of the North Sea flat country against floods and storm tides. Nowadays, in many places, regulatory bodies demand that financial institutions set aside capital reserves large enough to offset the risk of large monetary losses. These capital reserves play a role analogous to that of dikes along the seashore. After the devastating tidal wave that occurred in 1953, the government of the Netherlands started building large engineering structures to protect the shore. By taking costs and various technical constraints into account, the Delta Works Commission determined an acceptable level of flood risk for each of the relevant regions. For instance, it was agreed that in the south of Holland, dikes should be able to withstand a flood occurring at most once every 10000 years. How can one estimate such a risk when there are no data on the magnitude of a flood occurring once every 10000 years? Paul Embrechts explained that the theory of extreme values enables one to extrapolate beyond the observed values. It is noteworthy that the research carried out in this field is due, to a large extent, to probabilists and statisticians who grew up in the vicinity of the North Sea. Paul Embrechts himself was born a few days after the 1953 tidal wave, very close to the affected region.

In finance, the bestsellers by Nassim Nicholas Taleb have popularized the phrase "black swan," which denotes a rare and unpredictable event having major consequences. Thus it should not surprise us that in finance, the theory of extreme values can be used to predict and evaluate black swan events and try to avoid them.

As they say, it never rains but it pours! Large floods occur in several regions simultaneously; the movements of the stock market often trigger the simultaneous fall of many assets; and several debtors may all of a sudden become unable to fulfill their engagements. When they forget this, financial institutions underestimate their risk. In 2009 the media blamed the downfall of Wall Street on the "Gaussian copula", which financial analysts were using to compute the probability of multiple payment defaults (see for instance "The Formula that Killed Wall Street" in the *Financial Times* of April 24, 2009). Paul Embrechts told his audience that this comment by the media made as little sense as blaming the formula $E = mc^2$ (due to Einstein) for the destruction caused by atomic bombs! He also stated that it was ironical to accuse university researchers of having caused the crisis (at least indirectly), because they have never stopped pointing out the deficiencies of the methods used in the financial industry. As early as 1998, Paul Embrechts and his team had warned that the "Formula that Killed Wall Street" underestimated, to a considerable extent, the risk of simultaneous extreme events.

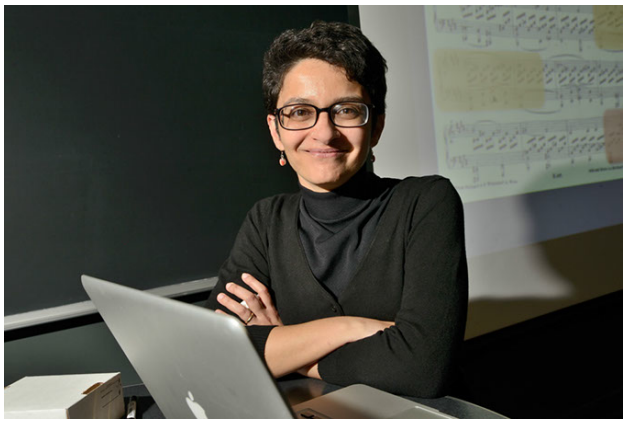
At the end of this fascinating lecture, many people in the audience must have pondered the concluding remark by Professor Embrechts, which concerned the importance of communication. Scientific excellence and best practices go hand in hand thanks to a constant dialogue. The powerful stochastic models and inference techniques that are available to us will yield their full potential only if their users listen to the researchers instead of considering them as scientists ensconced in their ivory towers.

Mathematics of Planet Earth 2013 — Cross-Canada Series of Lectures

The Mathematics of Light and Sound

Nilima Nigam (Simon Fraser University)

by Jacques Hurtubise (McGill University)



Nilima Nigam

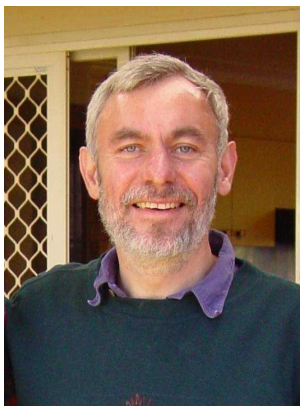
Within the framework of the MPE series organized by the Canadian Mathematical Society and the Canadian Mathematical Institutes, Professor Nilima Nigam gave a superb public lecture on February 15, 2013. In front of a large audience, she presented and developed variations on the themes of sound and light, especially focusing on the description, the understanding, and the exploration of these phenomena. Nilima Nigam gave a sweeping historical account of the study of light, from the Greeks (i.e., Empedocles) and the Romans (i.e., Lucretius), through the Indians of the same period (i.e., the school of Vaisheshika), to the 17th century (with Newton's experiments pointing to the corpuscular nature of light and Huygens' arguments in favour of the wave nature of light) and the 19th and 20th centuries (with experiments on diffraction and the photoelectric effect that led to the wave-particle duality).

As for sound, Nilima Nigam started from the harmony of spheres and spoke about the experiments for analyzing the harmonics of sound, while displaying sonograms of a few simple sounds but also of James Brown's voice. She analyzed for her audience the symmetries underlying Bach's music and explained the successive refinements in our understanding of the solutions to wave equations. She concluded her lecture with a very modern theme: the possibility of making some regions of the space impervious to sound or light waves by a fine-tuning of refraction indices. Although this has not been achieved in the case of visible light waves, it has been demonstrated recently that some regions can be made impervious to micro-waves or sound waves. In summary, Nilima Nigam gave us access to a broad spectrum of science and mathematics, which bodes well for the other lectures in the series (http://cms.math.ca/Events/MPE2013/).

The mathematics of 'fracking'

Anthony Peirce (University of British Columbia)

"Fracking" is used by the oil and gas industry to enhance the production of hydrocarbons. Recently there has been considerable controversy surrounding the fracking process due to environmental concerns. Fracking makes use of a process called hydraulic fracturing (HF) by which tensile fractures are induced to propagate in brittle materials by the injection of a pressurized viscous fluid. In his lecture Anthony Peirce provided examples of natural HF and situations in which HF techniques are used in industrial problems. Natural examples of HF include the formation of dykes by the intrusion of pressurized magma from deep chambers. They are also used in a multiplicity of engineering applications, including: the deliberate formation of fracture surfaces in granite quarries; waste disposal; remediation of contaminated soils; cave inducement in mining; and, as mentioned above, the fracturing of hydrocarbon bearing rocks in order to enhance productivity of oil and gas wells. Novel and emerging applications of this technology include CO2



Anthony Peirce

sequestration and the enhancement of fracture networks to capture geothermal energy.

Anthony Peirce showed how dimensional reasoning can be used to identify the fundamental power-law relationships between the variables depending on the balance between the dominant physical processes that are active. He described the governing equations in 1-2D as well as 2-3D models of HF, which involve a coupled system of degenerate nonlinear integro-partial differential equations as well as a free boundary. He demonstrated that a re-scaling of these models and dominant balance arguments can be used to identify special asymptotic solutions that are of crucial importance in the location of the fracture-free boundary. He also discussed the challenges for efficient and robust numerical modelling of the 2-3D HF problem and some techniques recently developed to resolve these problems, including: a novel Implicit Level Set Algorithm for solving the free boundary problem; an Extended Finite Element (XFEM) methodology for HF; and a Kalman Filter methodology to identify the location of propagating fractures from remote measurements. The efficacy of these techniques was demonstrated with numerical results. The interested reader may consult the site http://www.math.ubc.ca/~peirce.

Grandes Conférences du CRM

From Einstein to Wheeler: Throwing Some Light on the Wave-Particle Duality

Alain Aspect (Institut d'Optique, Palaiseau)

by Gilles Brassard (Université de Montréal)

Alain Aspect

On October 25, 2012, the lecture hall of the Goodman Agora was full of people enjoying a splendid "Grande Conférence" delivered with humour and rigour by Alain Aspect, a French physicist who is also a professor at the Institut d'Optique (Palaiseau, France). Alain Aspect is an expert popularizer of science: he apologized to his audience after his very first equation, saying that even people who cannot read music can appreciate a good concert. He is considered as a potential Nobel Prize winner, on account of work carried out at the beginning of the 1980s and demonstrating (on a distance of several meters) the reality of quantum intrication, a phenomenon viewed by Einstein as troublesome. Alain Aspect did not address this topic, however, but the wave-particle duality, a phenomenon whose complete reality was demonstrated for the first time by himself a few years later. Note that Richard Feynman, renowned for having said that the wave-particle duality is the first great mystery of quantum mechanics, changed his mind later on and acknowledged that intrication is as mysterious as duality. It is remarkable that Aspect's work shed light on two mysteries!

The conference began with a history of a fascinating question: what is the nature of light? More precisely, is it composed of waves or particles? From ancient Egypt and Greece, Alain Aspect led his audience to the debate between Huygens and Newton more than three centuries ago. Huygens could explain in a simple fashion the well-known phenomena of reflection and refraction while Newton argued that the chromatic decomposition of light through a prism indicated that light was composed of particles of various colours. Newton's fame ensured the adoption of his views by scientists, at least until the work of Young and Fresnel in 1822: it is then that the "wave" won out, because of interference, diffraction, and polarization phenomena, particularly the "Young's slits" experiment. This experiment consists of letting a beam of light go through two slits and observing so-called interference bands, i.e., bands that are alternatively bright and dark, on a screen behind the slits. Around thirty years later, Maxwell determined that light waves were actually electromagnetic waves. Everything seemed so clear at that point that one could be forgiven for thinking, at the end of the XIXth century, that the study of theoretical physics was complete. Lord Kelvin, however,

pointed out that two unexplained "clouds" remained, and these clouds gave rise to the two great revolutions in XXth century physics: relativity and quantum mechanics. Alain Aspect stated boldly that the latter was the most extraordinary theory ever devised by the human species.

In 1905 Einstein had the audacity of proposing a "particle" theory of light in order to explain the photoelectric effect. This heretical theory was not immediately accepted and Millikan tried to show that is was false through experiments, but these experiments actually corroborated Einstein's theory in 1915 and Einstein won the Nobel Prize for Physics in 1922. How can one reconcile this "particle definition" of light with the diffraction, interference, and polarization experiments by Young and Fresnel? Is light a wave or does it consist of particles? Einstein answered this question in 1909 by putting forward the wave-particle duality, which was at the heart of Alain Aspect's lecture. This theory postulates that light is composed of indivisible particles (which have been called "photons" since 1926), but that each photon can behave like a wave and in particular interfere with itself when going through two slits. How can we know whether this is a good model of light?

In the 1950s Feynman imagined a thought experiment with a purely pedagogical goal. If one could redo the Young slits' experiment by sending one photon at a time towards the slits, then one could exclude the classical theory, according to which a photon going through one of the slits interferes with another photon going through the other slit. Feynman was not suggesting to carry out this experiment since nobody was able to manipulate individual photons at the time! It is easy, however, to emit a light beam containing a number of photons following a Poisson law whose intensity can be chosen a priori. This seems to entail the feasibility of an experiment with a beam so thin that the photons would go through the slits one by one, like the drops of a faucet that leaks very slowly. Unfortunately this would not correspond to Feynman's experiment, since the Poisson law still allows for the possibility of several photons within a very short interval. Indeed, a mathematical computation shows that a purely clasical theory, in which no photon goes through more than one slit, accounts in an exact fashion for the interference phenomena that would be observed in such an experiment!

Therefore, if one wishes to realize Feynman's experiment in practice, one must get hold of a source of isolated photons (also called "unique photons"). This experiment was finally carried out in 1985 by Alain Aspect and his first doctoral student, Philippe Grangier. How does one produce unique photons? With a deadpan sense of humour, Alain Aspect began his explanation by giving us a so-called "kitchen recipe". While going from an excited state to its ground state, an atom produces one and only one photon. Thus to produce a unique photon, it suffices to take a single atom, to "excite" it, and to wait! Unfortunately no one knew how to isolate an atom in 1985. In looking for a method of producing unique photons, Alain Aspect took his inspiration from the montage that had allowed him to prove the existence of intrication a few years before. One designs an assembly of atoms emitting millions of photons every second, but these photons are emitted in pairs of different colours. Each emission of a green photon (551 nm) is followed, a few nanoseconds later, by the emission of a violet photon (423 nm). Hence one only has to detect green photons to know whether they are the "harbingers", with a high probability, of the emission of a unique violet photon. At the time this montage required a cumbersome equipment whose manipulation was akin to an art. Alain Aspect could not refrain from mentioning that this experiment can be carried out nowadays in a "disgustingly simple" fashion!

Alain Aspect and Philippe Grangier were at last able to realize the thought experiment proposed by Richard Feynman and to observe (naturally) the results predicted by quantum mechanics. Thus it took more than 75 years to verify the theory of wave-particle duality first stated by Einstein in 1909! But neither the story nor the lecture ended with this achievement: on the contrary, things became even more fascinating.

When our photon comes across a beam splitter, will it behave like a wave and follow the two paths simultaneously (like the photon of Young's experiment, which goes through the two slits at the same time) or like a particle and follow one of the two paths? It seems that this "decision" depends upon what will be "required" of the photon later on! If the two potential paths are recombined, then an interference phenomenon will occur, which suggests a "wave-like" behaviour. On the other hand, if one attemps to detect the two paths independently, only one of the "detections" will be successful, which suggests a "particle-like" behaviour. Does the photon that comes across a beam splitter have to "open out its antennas" (this is my phrase) in order to

choose a behaviour depending upon the continuation of its path? In 1978 John Archibald Wheeler proposed a thought experiment called "delayed choice", in which the continuation of the photon path is chosen randomly just after the photon has gone through the beam splitter. By now you must have guessed that Alain Aspect did also carry out this experiment (in 2007) and that quantum mechanics triumphed one more time! Note that other researchers had carried out this experiment before him, but not with a source of unique photons; hence their experiments did not prove anything. Alain Aspect concluded this section of his lecture by stating that "the delayed choice experiment is hard on the photon!" Being modest (as always), he added that his experiment had succeeded because "we had very good students." Let us mention particularly Vincent Jacques, the first doctoral student of Jean-François Roy, himself the first doctoral student of Philippe Rangier (Alain Aspect's first doctoral student, as you may recall). It is a great family history!

How is all of this possible? Alain Aspect suggested that "when one does not understand anything any more, one goes back to Niels Bohr" and added (with a smile) that Bohr's writings are "like those of Nostradamus." Indeed they are often very obscure. Aspect provoked the laughter of the audience by stating that in Bohr's explanations, one finds not only the wave-particle duality but the complementarity between accuracy and clarity. He also said that "with geniuses, one is allowed to make jokes!"

Aspect concluded his lecture by outlining the concept underlying quantum cryptography, which he calls a "true revolution" (thank you!) and proves that asking fundamental questions may lead to practical applications. Allow me to add: "Long live fundamental research!" Our unforgettable lecturer gave us a last present, a family snapshot depicting four generations of researchers: Vincent Jacques, Jean-François Roch, Philippe Grangier, and of course Alain Aspect himself. This magical night ended with thunderous applause.

Thank you Alain for your generosity!

CRM Partnerships

The CRM is strongly committed to its national mission and takes measures to ensure that as many Canadian scientists as possible benefit from its activities and become involved in their planning. For instance, it appoints to its International Scientific Advisory Committee eminent Canadian scientists from various parts of the country; it is present in all important forums where the future directions of the Canadian mathematical sciences are discussed; it urges its organizers to ensure that Canadian specialists are included in their activities; it organizes and supports scientific events across the country; it collaborates with Canadian institutes, societies, and associations. A specific budget is set aside each year for the participation of Canadian graduate students in its programs. The CRM is the only national institute that operates in the two official languages of Canada and it is highly visible on the international scene. In keeping with its national role, it coordinates its activities with the Fields Institute for Research in Mathematical Sciences, the Pacific Institute for the Mathematical Sciences (PIMS), the Mprime network, the Canadian Mathematical Society (CMS), the Canadian Applied and Industrial Mathematics Society (CAIMS), the Statistical Society of Canada (SSC), the Canadian Association of Physicists (CAP), as well as other societies and institutes abroad.

CRM Partners

The Fields Institute for Research in Mathematical Sciences and the Pacific Institute for the Mathematical Sciences

Since the early 1990s two other research institutes have joined the CRM on the Canadian scene: Toronto's Fields Institute for Research in Mathematical Sciences and the Pacific Institute for the Mathematical Sciences (PIMS). As well as coordinating their scientific activities, the three institutes have worked closely on a variety of initiatives, the most important of which is the Mprime network. The three institutes are also involved in other initiatives, such as the CRM–Fields–PIMS Prize awarded in recognition of outstanding accomplishments in the mathematical sciences in Canada. It was created in 1994 as the CRM–Fields Prize and became the CRM–Fields–PIMS Prize in 2006. The administrative responsibility for this prize rotates between the three institutes.

National and International Collaborations

The CRM collaborates with research centres in the Montréal area, especially the Groupe d'études et de recherche en analyse des décisions (GERAD). The CRM, the ISM, and GERAD jointly organize a weekly statistics colloquium (see the section General Program). The CRM is a partner of the Banff International Research Station (BIRS).

The researchers belonging to the CRM or a CRM laboratory enjoy close collaborations with French colleagues, in particular CNRS and INRIA researchers. In 2011 an Unité Mixte Internationale (UMI) of the CNRS was established at the CRM. This UMI supports visits of French mathematicians to members of the CRM and vice versa. In 2012-2013 the following French mathematicians visited the CRM: Marie Albenque (CNRS, Palaiseau), Mattia Cafasso (Angers), Pierre Conte (CEA/Saclay), Virgile Ducet (Ph.D. student in Marseille), Gérard Freixas i Montplet (CNRS, Paris), Emmanuel Fricain (Lille), Carlo Gasbarri (Strasbourg), Paolo Ghiggini (CNRS, Nantes), Pierre Ille (CNRS, Marseille), Muath Karaki (Ph.D. student in Lille and Lyon), Annalisa Panati (Toulon), Vincent Pilaud (CNRS, Palaiseau), Claude-Alain Pillet (Toulon), Jean-Philippe Préaux (Marseille), Erwan Rousseau (Marseille), and Sheila Sandon (CNRS, Strasbourg). Three Montréal researchers (Louigi Addario-Berry, from McGill, Laurent Habsieger, the UMI director, and Geña Hahn, from the Université de Montréal) visited colleagues in France thanks to the UMI. For more information we refer the reader to the site www.crm.umontreal.ca/UMI/. In 2012-2013 the relationship between the CRM and French researchers also resulted in the organization of two colloquia within the Entretiens Jacques-Cartier: a colloquium on risk management and a colloquium on mathematical physics. We refer the reader to the section on the CRM general program for reports on these colloquia.

The CRM has signed agreements with the European Union. For instance, in 2006 the CRM and the ISM signed an agreement with the ALGANT consortium (where ALGANT stands for Algebra, Geometry, Number Theory) to further the exchange of graduate students. In 2010 the CRM was one of the 12 partners to sign an agreement with SISSA (an Italian centre) to promote exchanges of visiting researchers specializing

in mathematical physics. SISSA (International School for Advanced Studies, in English) is based in Trieste and is a university dedicated to the training of graduate students. In December 2012 the CRM signed an agreement with the Institute of Mathematics and Computer Science of the Academy of Sciences of Moldova. The purpose of this agreement is to exchange professors for lectures and research projects, to conduct joint research projects, and to support joint supervision and tutoring of Ph.D. students.

The CRM has signed two agreements with the Tata Institute of Fundamental Research (TIFR), a prestigious research centre in India. The scope of the first agreement was applied mathematics and it was signed in 2006 between the CRM and the TIFR Centre for Applicable Mathematics in Bangalore. The scope of the second agreement was pure mathematics and was signed in 2011 between the CRM and the Mumbai TIFR.

In its publishing activities, the CRM is continuing its partnership with the American Mathematical Society (AMS), in particular through its two series of joint publications, the CRM Monograph Series and the CRM Proceedings & Lecture Notes. A CRM Series in Mathematical Physics is published by Springer. The CRM has exchange agreements with the Fields Institute for Research in Mathematical Sciences, PIMS, the MSRI, the Institute for Mathematics and its Applications (University of Minnesota), the École normale supérieure (France), the Isaac Newton Institute, the Institut des Hautes Études Scientifiques (France), and BIRS.

Associations and Professional Societies

The CRM maintains close ties with the different professional societies in the mathematical sciences: CMS, CAIMS, SSC, and CAP. The president of the CMS is an ex-officio member of the International Scientific Advisory Committee of the CRM. The CRM has also supported financially certain initiatives of the CMS, such as the mathematical camps. Together with the other institutes, the CRM organizes or sponsors special sessions at the CMS, CAIMS, and SSC meetings. The CRM awards a prize each year jointly with the SSC; similarly, it awards a prize each year with the CAP in mathematical and theoretical physics.

The Mprime Network

The Mprime network (www.mprime.ca) is the only Network of Centres of Excellence for the mathematical sciences, bringing together academia, industry, and the public sector to develop cutting edge mathematical tools vital to our knowledge-based economy. Known as Mitacs (Mathematics of Information Technology and Complex Systems) from 1999 to 2011, it is a pan-Canadian network whose creation was proposed by the three Canadian mathematical sciences institutes (the CRM, the Fields Institute for Research in Mathematical Sciences, and PIMS). The organization now called Mathematics of Information Technology and Complex Systems is not focused solely on mathematics but on the development of the next generation of innovators with vital scientific and business skills (see www.mitacs.ca).

The purpose of the Mprime network (formerly known as Mathematics of Information Technology and Complex Systems) was to lead Canada's effort in the generation, application, and commercialization of new mathematical tools and methodologies within a world-class research program. In order to do so, Mprime initiated and fostered linkages with industrial, governmental, and not-for-profit organizations. Mprime research focuses on five key sectors of the economy: biomedical and health sector; environment and natural resources; information processing; risk and finance; and communication, networks, and security.

Atlantic Association for Research in the Mathematical Sciences (AARMS)

AARMS was founded in March 1996 at a time when the National Network for Research in the Mathematical Sciences was being discussed and planned. AARMS exists to encourage and advance research in all mathematical sciences (including statistics and computer science) in the Atlantic region. In addition AARMS acts as a regional voice in discussions of the mathematical sciences on a national level. Since its inception, AARMS has played an important role in the research activities in the Atlantic region, sponsoring or co-sponsoring numerous meetings and workshops. In the summer of 2002, AARMS initiated an annual Summer School for graduate students and promising undergraduates. AARMS is grateful to Canada's three mathematical institutes (the CRM, the Fields Institute for Research in Mathematical Sciences, and PIMS), as well as to the member universities, for providing funding for its activities. Its member universities are Acadia University, Cape Breton University, Dalhousie University, Memorial University of Newfoundland, Mount Allison Uni-

versity, St. Francis Xavier University, Saint Mary's University, the Université de Moncton, the University of New Brunswick, and the University of Prince Edward Island. Finally AARMS receives some financial support from the provinces of New Brunswick and Nova Scotia. One can find information on the activities of AARMS at the following web site: http://www.aarms.math.ca.

Academic Partners

The activities of the CRM rest on a solid basis of cooperation with regional universities, in particular the Montréal universities, and most particularly the Université de Montréal, whose support for the CRM has been unfailing. The Université de Montréal releases five of its faculty members to work at the CRM each year, and the support of these faculty members is an essential asset for the scientific activities of the CRM. There is in addition a regular program of teaching releases for the other Montréal universities, bringing the equivalent of another two positions to the CRM each year. On an ad-hoc basis linked to the thematic program, the CRM has also been arranging the release of research personnel from nearby universities such as Laval, Sherbrooke, Queen's, and Ottawa. The partnerships of the CRM with the other research institutes in the Montréal area have been very profitable.

With the financial support of the Université de Montréal, McGill University, the Université du Québec à Montréal, Concordia University, and Université Laval, as well as grants from NSERC and the Fonds de recherche du Québec – Nature et technologies (FRQNT), the CRM finances the activities of its nine laboratories, which collectively represent the most active branches of the mathematical sciences. These laboratories are the perfect illustration of scientific vitality and serve to feed the national and international scientific programs of the CRM. The reader may refer to the section Research Laboratories for a description of the activities of each of these laboratories.

Association with the University of Ottawa

In 2003, the Department of Mathematics and Statistics of the University of Ottawa became a member of the CRM. In partnership with the University of Ottawa, the CRM cofinances the CRM–University of Ottawa Distinguished Lecture Series, postdoctoral fellowships, and teaching releases so that University of Ottawa faculty members can undertake research with colleagues in the laboratories of the CRM or participate in the scientific activities of the CRM.

CRM–University of Ottawa Distinguished Lecture Series

The series features talks by prominent mathematicians from Canada and abroad on topics at the forefront of today's mathematical research. In 2012–2013 there were two such talks at the University of Ottawa.

Free probability and random matrices, by Alice Guionnet (MIT), on March 1st, 2013

Familles d'algèbres de quaternions et d'octonions, by Philippe Gille (École Normale Supérieure, Paris), on April 5, 2013

Network for Computing and Mathematical Modeling (ncm_2)

The CRM is one of the founding members of the Network for Computing and Mathematical Modeling (ncm_2), a network created by several research centres in order to respond to the needs of industry in fields related to computing and mathematical modelling. The research of the network focuses on five major themes: risk management, information processing, imaging and parallel computing, transport and telecommunications, and health and electronic commerce. The ncm_2 was founded by the CRM, the Centre de recherche en calcul appliqué (CERCA), the Center for Interuniversity Research and Analysis on Organizations (CIRANO), the Centre for Research on Transportation (CRT), the Computer Research Institute of Montréal (CRIM), and the Institut national de la recherche scientifique – Télécommunications (INRS-Télécom). At the present time the following centres are members of the ncm_2: CIRANO, CRM, CIRRELT, INRS-ÉMT, and GERAD.

Regroupement Neuroimagerie/Québec (RNQ)

In recent years, the PhysNum laboratory of the CRM has developed a strong collaborative network with various partners in neuroimaging in the Montréal area. This network became an officially recognized network with the founding of the Regroupement Neuroimagerie/Québec (RNQ), under the umbrella of the Insti-

tut universitaire de gériatrie de Montréal. One of the strongest alliances of the CRM within that network is its association with the Inserm laboratory for brain imaging at FMPMC Pitié-La Salpêtrière (Paris), whose director is Dr. Habib Benali.

Joint Initiatives

The annual meetings of the CMS, SSC, and CAIMS, as well as some of their training and promotion activities, are jointly sponsored by the CRM, the Fields Institute for Research in Mathematical Sciences, PIMS, and Mprime. The annual meetings of the societies allow Canadian mathematicians and statisticians to keep abreast of their colleagues' work, to organize sessions on emerging topics, and attend lectures given by world-renowned mathematicians or prize winners. One can find more information on the societies by consulting their respective web sites (http://www.cms.math.ca/, http://www.ssc.ca/, and http://www.caims.ca/). Note that the CRM was the host of the 2012 CMS Winter Meeting, which took place at the Fairmont Queen Elizabeth Hotel in Montréal.

2012 CMS Summer Meeting
June 2–4, 2012, Regina
http://cms.math.ca/Events/summer12/

40th Annual Meeting of the Statistical Society of Canada
June 3–6, 2012, Guelph
http://www.ssc.ca/en/meetings/2012/

Canadian Applied and Industrial Mathematics Annual Meeting, CAIMS 2012
June 24–28, 2012, the Fields Institute for Research in Mathematical Sciences
http://www.fields.utoronto.ca/programs/scientific/11-12/CAIMS_SCMAI/

2012 CMS Winter Meeting
December 7–10, 2012, Fairmont Queen Elizabeth, Montréal
http://cms.math.ca/Events/winter12/

Mathematical Education

As part of its mandate to promote and stimulate research in the mathematical sciences, at every level, the CRM provides funding and support for many activities and programs related to mathematical education and the training of researchers. Many of these activities and programs are carried out jointly with the ISM (Institut des sciences mathématiques). As a result, much of the information contained in the present section is taken from the ISM annual report.

Institut des sciences mathématiques (ISM)

Created in 1991 by the departments of mathematics and statistics of the four Montréal universities, the ISM is a consortium of eight Québec universities (Bishop's University, Concordia, Laval, McGill, Université de Montréal, UQAM, UQTR, and Université de Sherbrooke), six of which offer a Ph.D. program in Mathematics. As an institute to which belong almost all the Québec researchers in the mathematical sciences, the ISM has at its disposal vast material and intellectual resources, and as a result, Montréal and Québec itself have become one of the main centres of training and research in the mathematical sciences in North America. The ISM is funded by the Ministère de l'Éducation, du Loisir et du Sport du Québec and by the eight universities in the consortium.

The reader will find below an overview of the activities and programs of the ISM.

- Coordination and harmonization of graduate programs

The ISM was created to bring together the strengths of its member departments, in order to turn them into a great school of mathematics. Thus the ISM coordinates the graduate studies of the mathematics departments, supports the sharing of expertise among its researchers, and facilitates student mobility between the Montréal universities.

- Scholarships and financial support

The ISM helps students and beginning researchers carry out their research activities in several ways, for instance through the ISM Scholarships for Graduate Studies, the Carl Herz Scholarship (financed by the Carl Herz Foundation), the Travel Bursaries, the Undergraduate Summer Scholarships, and the CRM–ISM postdoctoral fellowships.

- Scientific activities

Since its creation, the ISM has initiated several activities that are by now an integral part of the Québec scientific scene: the CRM–ISM Mathematics Colloquium, the CRM–ISM–GERAD Statistics Colloquium, the CRM–ISM Probability Seminar, and the ISM Graduate Student Conference.

- Promotion of the mathematical sciences

The ISM produces the *Accromath* journal and distributes it freely in all the cégeps and secondary schools in Québec. In this way, it contributes to spreading mathematical knowledge among teachers, young students, and the general public. Each year, ISM professors give talks attended by thousands of cégep students; these talks present the latest breakthroughs in mathematics and the careers available to mathematics graduates.

As the above list demonstrates, the CRM has several joint activities with the ISM, in particular two colloquia, a joint program of postdoctoral fellowships, and the planning of graduate courses related to the thematic programs of the CRM. Since the summer of 2003, the CRM has also supported the Undergraduate Summer Scholarships program, which allows postdoctoral fellows to supervise undergraduate students doing research.

CRM–ISM Postdoctoral Fellowships

The CRM–ISM postdoctoral fellowships enable promising young researchers to devote themselves to their research work. The ISM organizes a single competition on behalf of the eight universities of the consortium, and it receives a large number of applications, which are then evaluated by the 150 ISM professors. The selection of the fellows is rigorous and only one in forty applicants is awarded a fellowship. The applications are handled electronically in order to streamline the selection process and economize the resources consumed during the selection. The postdoctoral fellows play a crucial role in the Montréal universities: they collaborate with the established researchers, stimulate their work, and bring new ideas from other great centres of mathematical research. Also they are a vital link between the professors and the students, espe-

cially when they organize on their own study groups on emerging topics.

CRM–ISM 2012–2013 Postdoctoral Fellows

Jessica Banks (Ph.D., Oxford) works with Steven Boyer in the field of low-dimensional topology, especially knot theory.

Vorrapan Chandee (Ph.D., Stanford) works with Chantal David and Andrew Granville on analytic and probabilistic number theory, L-functions, the theory of random matrices, and quadratic forms.

Adam Harper (Ph.D., Cambridge) works with Andrew Granville in analytic number theory.

Dmitry Kolomenskiy (Ph.D., Université de Provence) works in applied mathematics with Robert Owens and Jean-Christophe Nave.

Antonio Lei (Ph.D., Cambridge) works with Henri Darmon in algebraic number theory.

Alejandro Morales (Ph.D., MIT) works with François Bergeron in algebraic and enumerative combinatorics.

Yakov Savelyev (Ph.D., Stony Brook) works with Octav Cornea and François Lalonde in symplectic and differential geometry. His main interests are Floer theory and Gromov-Witten theory in dynamical systems and mathematical physics.

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
Duration : May 1 – August 31 (4 months)

Nicholas Galbraith (McGill)
Scholarship co-financed by Steven Boyer
Supervisor : Jessica Banks
Topic : Physical Knot Theory
Duration : May 1 – July 15 (2,5 months)

Olivier Gingras (Montréal)
Scholarship co-financed by Pavel Winternitz
Supervisor : Danilo Riglioni
Topic : Superintegrable systems
Duration : May 1 – August 31 (3.5 months)

Samuel Laferrière (McGill)
Scholarship co-financed by Frédéric Rochon
Supervisor : Carl Tipler
Topic : Riemann-Roch theorem on singular surfaces
Duration : May 1 – July 31 (3 months)

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
Duration : May 1 – July 31 (3 months)

Manuela Pineros-Rodriguez (Montréal)
Scholarship co-financed by Dimitris Koukoulopoulos
Supervisor : Mariah Hamel
Topic : Encryption, factorization, and primality testing algorithms
Duration : May 1 – August 31 (4 months)

William Wright (McGill)
Scholarship co-financed by Henri Darmon
Supervisor : Miljan Brakocevic
Topic : Rational points on modular elliptic curves
Duration : May 1 – August 31 (4 months)

Dongliang Zhang (McGill)
Scholarship co-financed by David Stephens
Supervisor : Will Astle
Topic : Model selection in complex settings
Duration : May 1–August 31 (4 months)

ISM Graduate Student Conference

Each year the ISM sponsors and supports the organization of the ISM Graduate Student Conference ("Colloque pan-québécois des étudiants de l'ISM"). Organized by and for the students of the partner universities, the 14th Conference was held on May 17–19, 2013, at McGill University. It was organized by Hadi Bigdely, Kael Dixon, Olivier Mercier, and Juan Ignacio Restrepo and attended by around 80 participants. The program featured five plenary lectures and presentations by students. The plenary lectures were given by Marc Lackenby from the University of Oxford (*Reidmeister moves for the unknot*), Robert Pollack from

Boston University (*Congruences and families of modular forms*), David Wolfson from McGill University (*The Statistical analysis of survival data : A personal journey*), Yves Bourgault from the University of Ottawa (*Modèles et calculs en électrophysiologie cardiaque*), and Mohammad Najafi Ivaki from Concordia University (*Centro-affine normal flows*). Note that Mr. Ivaki was awarded the Carl-Herz Prize for 2013.

The following students gave talks during the Conference: Adam Alcolado (McGill), Jean Auger (Laval), Mohammad Bardestani (Montréal), Léo Belzile (McGill), Yara Elias (McGill), Marc Éthier (Sherbrooke), Andrew Fiori (McGill), Alexandre Foucault (Montréal), Patrick Letendre (Laval), Maryam Lotfipour (Montréal), Thierry Moisan (Laval), Leta Montopoli (McGill), Sébastien Picard (McGill), Emilie Picard-Cantin (Laval), Benoît Pouliot (Laval), Ben Smith (McGill), Mashbat Suzuki (McGill) et Jean-Sébastien Turcotte (Montréal).

Promotion of the Mathematical Sciences

Produced by the ISM and financed by the ISM, the CRM, the CMS, and the Mprime network, the Accromαth magazine aims to draw more young people to the mathematical sciences. Accromαth, whose editor-in-chief is André Ross, has two issues per year and is available free of charge in all the high schools and cégeps of Québec. Accromαth is designed by an exceptional team of researchers and instructors with a broad experience in the promotion of mathematics; it provides high school and cégep teachers with stimulating and topical articles on the most recent discoveries and applications, as well as articles on the history of mathematics and its links with the arts.

The last year was particularly fruitful for Accromαth. The Spring 2013 issue was devoted to the Mathematics of Planet Earth, so as to be included in the worldwide year on the same theme. More than 8000 copies of that issue were printed, thanks to the extraordinary support of the Canadian Mathematical Society ($1200) and the FRQNT ($2000). Copies of the special issue were also printed and distributed in 14 French-speaking African countries, thanks to the support of the Canadian Commission for Unesco ($3000), the International Commission on Mathematical Instruction ($1000 US), UNESCO ($2000), and the International Mathematical Union (€2000).

Other Joint Initiatives

56e Congrès de l'Association Mathématique du Québec

October 12–13, 2012, Cégep de Sainte-Foy

As usual the CRM was a sponsor of the "Association Mathématique du Québec" conference, which took place at the Cégep de Sainte-Foy and whose theme was *Les mathématiques ludiques* (*Recreational mathematics*).

"Sciences et mathématiques en action" and "Association québécoise des jeux mathématiques"

The CRM contributes to the "Sciences et mathématiques en action" program, created by Professor Jean-Marie De Koninck from Université Laval in order to popularize mathematics and science for high school students and the general public. We refer the reader to the site www.smac.ulaval.ca for more information. The CRM also supports the Association québécoise des jeux mathématiques (aqjm.fsg.ulaval.ca).

Research Laboratories

In 2012–2013 the CRM was encompassing nine research laboratories at the heart of the Québec mathematical community. These research groups act as focal points for local scientific activity and participate actively in the scientific programs of the CRM.

Applied Mathematics

Description

The Applied Mathematics Laboratory is a research network of 23 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 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.

News and highlights

The Applied Mathematics Laboratory has strengths in traditional areas of continuous applied mathematics (notably partial differential equations, applied analysis, and numerical methods), but discrete mathematics and optimization are increasingly important in applications. From now on these topics will be well represented in the Laboratory, because two McGill professors working in discrete mathematics have joined the Laboratory: Adrian Vetta (algorithmic game theory) and Bruce Shepherd (combinatorial optimization and graph theory). In the 2012–2013 academic year 17 M.Sc. students, 27 Ph.D. students, and 15 postdoctoral fellows were supervised or cosupervised by members of the Applied Mathematics Laboratory. About 10 of these students and PDFs graduated in 2012–2013 and they have moved on to positions in industry (Oracle, Nuance) and academia (Texas at Austin, Grenoble, Montréal, INRS).

Members of the Laboratory

Regular members

Robert G. Owens (Montréal), Director (until January 8th, 2013)
Mechanics, numerical simulation of complex fluids

Adam M. Oberman (McGill), Director (from January 8th, 2013)
Numerical solution and analysis of nonlinear elliptic partial differential equations

André D. Bandrauk (Sherbrooke)
Quantum chemistry

Peter Bartello (McGill)
Turbulence, CFD

Jacques Bélair (Montréal)
Dynamical systems in physiology

Anne Bourlioux (Montréal)
Modelling, numerical simulation in turbulent combustion

Xiao-Wen Chang (McGill)
Numerical linear algebra and applications

Rustum Choksi (McGill)
Calculus of variations, nonlinear partial differential equations, problems arising in materials science, self-assembly of diblock copolymers and magnetic domain formation in type-1 superconductors and ferromagnets

Eusebius J. Doedel (Concordia)
Numerical analysis, dynamical systems, differential equations, bifurcation theory, scientific software

Eliot Fried (McGill)
Mechanics and thermodynamics of continuous media

George Haller (McGill)
Theory of nonlinear dynamical systems, fluid mechanics, Hamiltonian systems, singular perturbation theory

Antony R. Humphries (McGill)
Numerical analysis, differential equations

Emmanuel Lorin de la Grandmaison (Carleton)
Numerical analysis for hyperbolic systems, quantum chemistry, complex applications of finite volumes, computer science

Sherwin A. Maslowe (McGill)
Asymptotic methods, fluid mechanics

Jean-Christophe Nave (McGill)
Numerical analysis, PDE, interface problems, level set methods, fluid mechanics, computer graphics

Gantumur Tsogtgerel (McGill)
Applied mathematics, partial differential equations, general relativity

Jian-Jun Xu (McGill)
Asymptotics and numerical analysis, nonlinear PDEs, materials science

Associate members

Tucker Carrington (Queen's)
Chemical dynamics

Martin J. Gander (Genève)
Domain decomposition, preconditioning

Jean-Philippe Lessard (Laval)
Dynamical systems, rigourous computational methods, PDEs, delay differential equations, topological methods

Nilima Nigam (Simon Fraser)
Applied analysis, numerical methods in electromagnetism

Paul F. Tupper (Simon Fraser)
Numerical analysis, stochastic processes, statistical mechanics

Thomas P. Wihler (Bern)
Numerical analysis, computational methods for PDEs

Jean-Paul Zolésio (INRIA Sophia Antipolis)
Control, optimization

CICMA — Centre Interuniversitaire en Calcul Mathématique Algébrique

Description

CICMA brings together researchers working in number theory, geometric group theory, and algebraic geometry. Algebraic geometry is a broad discipline with strong connections to a variety of areas ranging from arithmetic to theoretical physics. Eyal Goren and Adrian Iovita are leading experts in applying algebro-geometric techniques to problems motivated by number theory, notably the study of Shimura varieties and p-adic cohomology theories. John McKay is one of the instigators of the moonshine program, which ties together in a surprising way certain notions in the theory of modular forms, arithmetic geometry, and theoretical physics. Geometric group theory is a vibrant subject that has melded geometric and algebraic methods in deep and powerful ways, leading to novel insights in both subjects. Dani Wise and Mikaël Pichot are world-renowned specialists in this central area.

Contemporary algebraic number theory has developed over the last decades following two major trends. On one hand, there is the theory of special values of L-functions attached to arithmetic objects, originating in the work of Gauss and Dirichlet and leading to the modern conjectures of Deligne, Beilinson, and Bloch–Kato. On the other hand, the Langlands program postulates a close link between arithmetic L-functions and automorphic representations. Analytic number theory studies profound and subtle questions about the distribution of prime numbers, using powerful techniques from analysis, notably the theory of functions of a complex variable 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 Lalín on the more analytic side of the subject.

News and highlights

CICMA is well known internationally for attracting top quality students and PDFs from around the world. Each year the Laboratory organizes a dazzling array of activities that foster the exchange of ideas between students and researchers, from Montréal and the rest of the world: (a) the Québec-Vermont Number Theory Seminar (which has become the most important

forum in Canada for the presentation of the latest developments in number theory); (b) the Québec- Maine Conference; (c) the Montreal-Toronto Workshops in Number Theory; (d) the Bellairs Workshop in Number Theory (the topic of the May 2013 workshop was "Arithmetic intersection theory on Shimura varieties and derivatives of L- functions"); (e) the SHAPE (Séminaire Henri-Adrian-Payman-Eyal); and (f) The Analytic Number Theory Seminar. In the 2012–2013 academic year 5 undergraduate students, 28 M.Sc. students, 42 Ph.D. students, and 16 postdoctoral fellows were supervised or cosupervised by CICMA members.

Regular members of the Laboratory

Henri Darmon (McGill), Director
Algebraic number theory, arithmetic geometry, L-functions, Diophantine equations, elliptic curves

Hugo Chapdelaine (Laval)
Algebraic number theory, algebraic geometry

Chris J. Cummins (Concordia)
Group theory, modular functions, moonshine

Chantal David (Concordia)
Analytic number theory, L-functions

Jean-Marie De Koninck (Laval)
Analytic number theory: distribution of prime numbers, factorization of numbers, asymptotic behaviour of arithmetic functions, Riemann zeta function

David S. Dummit (Vermont)
Algebraic number theory, arithmetic algebraic geometry, computational mathematics

David Ford (Concordia)
Computational number theory, algorithmic number theory

Jayce R. Getz (McGill)
Number theory

Eyal Z. Goren (McGill)
Arithmetic geometry, algebraic number theory, moduli spaces of abelian varieties, Hilbert modular forms, p-adic modular forms

Andrew Granville (Montréal)
Analytic number theory, arithmetic geometry, combinatorics

Heekyoung Hahn (McGill)
Eisenstein series, L-functions, trace formula, q-series, theta functions and partitions

Adrian Iovita (Concordia)
Number theory, p-adic cohomology

Olga Kharlampovich (McGill)
Combinatorial group theory and Lie algebras

Hershy Kisilevsky (Concordia)
L-functions, Iwasawa theory, elliptic curves, class field theory

John Labute (McGill)
Pro-p-groups, Lie algebras, Galois theory

Matilde Lalín (Montréal)
Mahler measures, L-functions, zeta functions

Claude Levesque (Laval)
Algebraic number theory, units, class number, cyclotomic fields

Michael Makkai (McGill)
Mathematical logic

John McKay (Concordia)
Computational group theory, sporadic groups, computation of Galois groups

M. Ram Murty (Queen's)
Number theory: Artin's conjecture, elliptic curves, modular forms, automorphic forms, Langlands program, Selberg's conjectures, sieve methods, cryptography

Damien Roy (Ottawa)
Transcendental number theory

Peter Russell (McGill)
Algebraic geometry

Francisco Thaine (Concordia)
Cyclotomic fields, cyclotomy, rational points on curves

CIRGET — Centre Interuniversitaire de Recherches en Géométrie et Topologie

Description

Geometry and topology are fundamental disciplines of mathematics whose richness and vitality, evident throughout human 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 seventeen full members, four 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; non-linear partial differential equations in Riemannian geometry, convex geometry, and general relativity; and Hamiltonian dynamical systems.

News and highlights

In 2012–2013 CIRGET and its members prepared and organized three major events: the 2012–2013 Thematic Year; the short program on Rational Points, Rational Curves and Entire Holomorphic Curves on Projective Varieties; and the SMS 2013 Summer School. With the CRM, CIRGET was able to leverage additional funding from a number of international sources, including over $200,000 from the NSF to support young American mathematicians who participated in the activities. Nine of CIRGET's doctoral students and PDFs finishing in 2012–2013 have obtained positions (tenure-track or permanent): two in Canada, one in Scotland, one in Australia, and 5 in France. In the 2012–2013 academic year one undergraduate student, 25 M.Sc. students, 30 Ph.D. students, and 24 postdoctoral fellows were supervised or cosupervised by CIRGET members.

Members of the Laboratory

Regular members

Vestislav Apostolov (UQAM), Director
Complex geometry, Kähler geometry

Steven Boyer (UQAM)
Topology of manifolds, low-dimensional geometry and topology

Abraham Broer (Montréal)
Algebraic transformation groups, invariant theory

Virginie Charette (Sherbrooke)
Discrete group actions on affine varieties, Lorentz manifolds, Riemann surfaces discretization, discrete differential geometry

Olivier Collin (UQAM)
Invariants of knots and 3-manifolds arising from global analysis

Octav Cornea (Montréal)
Algebraic topology, dynamical systems

Pengfei Guan (McGill)
Partial differential equations, geometric analysis, several complex variables

Jacques Hurtubise (McGill)
Algebraic geometry, integrable systems, gauge theory, moduli spaces

André Joyal (UQAM)
Algebraic topology, category theory

Niky Kamran (McGill)
Geometric approach to partial differential equations

François Lalonde (Montréal)
Symplectic topology and geometry, global analysis on manifolds, infinite dimensional transformation groups

Steven Lu (UQAM)
Chern number inequalities, semistability of tensorial sheaves, log jets, log and hyperbolic geometry, algebraic degeneracy

Iosif Polterovich (Montréal)
Geometric analysis, spectral theory, functional analysis, differential geometry, partial differential equations

Frédéric Rochon (UQAM)
Geometric analysis, global analysis on singular spaces, index theory on manifolds with boundary

Peter Russell (McGill)
Algebraic geometry

Johannes Walcher (McGill)
Mirror symmetry for open strings, nongeometric string compactifications

Daniel T. Wise (McGill)
Geometric group theory, low-dimensional topology

Associate members

S. Twareque Ali (Concordia)
Coherent states, wavelets, quantization techniques, harmonic analysis, Wigner functions

John Harnad (Concordia)
Mathematical physics, classical and quantum physics, geometrical methods, integrable systems, group theoretical methods, random matrices, isomonodromic deformations, isospectral flows

Dmitry Jakobson (McGill)
Pure mathematics, global analysis, spectral geometry, quantum chaos, harmonic analysis, eigenvalues and eigenfunctions

John A. Toth (McGill)
Microlocal analysis, partial differential equations

GIREF — Groupe Interdisciplinaire de Recherche en Éléments Finis

Description

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. Thus the members of GIREF ("Groupe Interdisciplinaire de Recherche en Éléments Finis," or in English "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 some 27 member researchers reflect the interdisciplinary nature of the Laboratory and are based at the Université Laval, the École Polytechnique de Montréal, as well as the Universities of Moncton, Ottawa, and Alberta.

News and highlights

GIREF is active in fluid and solid mechanics. Its industrial partnerships, notably in the fields of pneumatics and manufacturing of wood-based products, give a very applied flavour to the research carried out by its members (especially within the NSERC Research Chair in High Performance Scientific Computing held by A. Fortin). GIREF also applies mathematical techniques to problems from biology. GIREF was the official host of the Annual Meeting of the Canadian Applied and Industrial Mathematics Society (CAIMS), which gathered over 200 participants in Québec City in June 2013. In 2013 GIREF recruited N. Doyon, an expert on digital modelling in the neurosciences, who is now a member of the biomedical modelling group along with Garon (École Polytechnique), Delfour (Université de Montréal), and Bourgault (University of Ottawa). In the 2012–2013 academic year one undergraduate student, 12 M.Sc. students, 11 Ph.D. students, and 4 postdoctoral fellows were carrying out research at GIREF.

Regular members

André Fortin (Laval), Director
Finite elements method, instationary viscous flows, mixing problems

André Garon (Polytechnique Montréal), Deputy Director
Thermohydraulics, fluid mechanics, finite elements method, hydraulic turbines, mechanics of biofluids: stents and pumps

Youssef Belhamadia (Alberta)
Mathematical modelling and numerical simulation of phase change problems, adaptive meshing for instationary problems in 2 and 3 dimensions, numerical modelling of cryosurgery, numerical modelling of the electromechanical wave in the heart

Yves Bourgault (Ottawa)
Computational fluid dynamics, numerical methods, finite elements method, mathematical modelling, mechanics of continuous media

Michel C. Delfour (Montréal)
Control, optimization, design, shells, calculus, biomechanics

Michel Fortin (Laval)
Numerical analysis of partial differential equations, numerical methods in fluid mechanics, optimization and optimal control for partial differential equations

Robert Guénette (Laval)
Numerical methods in non-Newtonian fluid mechanics, rheological models, Hamiltonian formulation

Hassan Manouzi (Laval)
Numerical analysis, applications of mathematics to engineering

Dominique Pelletier (Polytechnique Montréal)
Fluid mechanics and heat transfer, finite elements method, adaptive finite elements methods for compressible and incompressible flows, modelling and simulation of laminar and turbulent viscous flows, modelling and simulation of fluid-structure interactions

Roger Pierre (Laval)
Numerical analysis of partial differential equations

José Urquiza (Laval)
Numerical analysis, control of partial differential equations

Associate members

Pierre Blanchet (FPInnovations)
Nanotechnology for wood products

Alain Charbonneau (UQO)
Numerical simulation of optical wave guides, finite elements method, numerical methods, statistical machine translation, automated text categorization

Alain Cloutier (Laval)
Forestry, forest engineering

Marie-Laure Dano (Laval)
Mechanics and production of composite materials, intelligent mechanical systems

Claire Deschênes (Laval)
Axial hydraulic turbines

Guy Dumas (Laval)
Mechanical engineering, physics of fluids

Mohamed Farhloul (Moncton)
Finite elements and finite volumes method, partial differential equations, applications of the mixed finite elements method to fluid mechanics, numerical analysis

Marie-Isabelle Farinas (UQAC)
Modelling, numerical simulation, computational fluid mechanics, design of turbo engines (cardiac pump), optimization

Vincent François (UQTR)
Integration of the finite elements method into computer-aided design

Yves Fortin (Laval)
Forestry, forest engineering

Augustin Gakwaya (Laval)
Aerospatial and aeronautical engineering, numerical modelling, computer-assisted design

Guy Gendron (Laval)
Composite materials, optimization and modelling of structures

Jean-François Hétu (NRC-IMI)
Numerical modelling of processes

Jean-Loup Robert (Laval)
Numerical models of free surface flows, transport and diffusion models with stochastic components, unified modelling in a saturated and aerated environment

Yves Secretan (INRS-ETE)
Numerical methods for finite elements, mesh generation and adaptation, error estimation, hydrodynamics in 2 dimensions, advection-diffusion phenomena

René Therrien (Laval)
Underground water flows, hydrology, geothermics

LaCIM — Laboratoire de Combinatoire et d'Informatique Mathématique

Description

LaCIM (French acronym meaning "Combinatorics and Mathematical Computer Science 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 15 regular members, 5 associate members, and 16 collaborating members. 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 combinatorial optimization.

News and highlights

The main research areas of LaCIM are algebraic combinatorics, bioinformatics, and mathematical computer science. The support of the CRM has made it possible for 8 full-time postdocs to be involved in the LaCIM research activities, on top of all the graduate students and undergraduate trainees. It is noteworthy that 25% of the talks at this year's edition of FPSAC (the main international conference in algebraic combinatorics and a very selective one) have coauthors who are (current or past) PDFs or students of LaCIM. The expertise of the CRM in organizing meetings helped LaCIM hold an international conference in Cetraro, Italy, in July 2013 ("Words, Codes, and Algebraic Combinatorics – A conference in honor of Christophe Reutenauer's 60th birthday"). In the 2012–2013 academic year 18 M.Sc. students, 28 Ph.D. students, and 10 postdoctoral fellows were supervised or cosupervised by LaCIM members.

Members of the Laboratory

Regular members

Srečko Brlek (UQAM), Director
Combinatorics of words, algorithmics

Ibrahim Assem (Sherbrooke)
Representation theory

Anne Bergeron (UQAM)
Bioinformatics

François Bergeron (UQAM)
Combinatorics, algebra, representations of finite groups

Thomas Brüstle (Sherbrooke & Bishop's)
Algebraic combinatorics, cluster algebras, triangulations of surfaces, stochastic differential equations, mathematical models in finance

Cedric Chauve (Simon Fraser & UQAM)
Enumerative combinatorics, trees, bioinformatics

Sylvie Hamel (Montréal)
Bioinformatics and algorithms, theory of languages and automata, algebraic combinatorics

Christophe Hohlweg (UQAM)
Algebra, algebraic combinatorics, convex geometry

Gilbert Labelle (UQAM)
Enumerative combinatorics, analysis

Shiping Liu (Sherbrooke)
Representation theory

Vladimir Makarenkov (UQAM)
Computational biology, mathematical classification

Marni Mishna (Simon Fraser)
Algorithms and enumerative, analytical, and algebraic combinatorics

Christophe Reutenauer (UQAM)
Algebraic combinatorics, noncommutative algebra, automata theory, coding theory, free algebras

Franco Saliola (UQAM)
Algebraic combinatorics, group representations

Timothy R. S. Walsh (UQAM)
Algorithmics, enumerative combinatorics, graph theory

Associate members

Pierre Lalonde (Maisonneuve)
Enumerative and bijective combinatorics, alternating sign matrices, enumeration of involutions with respect to various parameters, use of Pfaffians and determinants in enumeration

Cédric Lamathe (UQAM)
Combinatorics of tree-like structures, theory of species, indicator series of partially labeled structures and asymmetric structures

Luc Lapointe (Talca)
Algebraic combinatorics, symmetric functions, integrable systems, supersymmetries

Odile Marcotte (UQAM & CRM)
Combinatorial optimization, integer programming, graph theory

Dominic Rochon (UQTR)
Complex analysis, hypercomplex numbers

Collaborating members

Marcello Aguiar (Texas A&M)
Algebraic combinatorics, non-commutative algebra, Hopf algebras and quantum groups, category theory

Robert Bédard (UQAM)
Representations of finite groups, Lie theory

Luc Bélair (UQAM)
Mathematical logic, model theory

Nantel Bergeron (York)
Applied algebra

Pierre Bouchard (UQAM)
Commutative algebra, algebraic geometry and combinatorics

Michel Bousquet (Vieux-Montréal)
Enumeration of combinatorial structures, planar maps and cacti, theory of species, Lagrange inversion formulas

Yves Chiricota (UQAC)
Computer graphics, mathematical methods in computer graphics, combinatorics, computational geometry, symbolic computation

Sylvie Corteel (LIAFA & CNRS)
Enumerative and bijective combinatorics, partitions of integers, q-series

Adriano Garsia (UC San Diego)
Algebraic combinatorics, symmetric functions, harmonic and coinvariant spaces, quasiharmonic and quasi-invariant functions

Alain Goupil (UQTR)
Combinatorics, algebra, linear representations of groups, symmetric group

André Joyal (UQAM)
Algebraic topology, category theory

Jacques Labelle (UQAM)
Combinatorics, topology

Louise Laforest (UQAM)
Data structures, combinatorics, asymptotic analysis, quaternary trees

Daniel Lemire (TÉLUQ)
Database theory, data warehousing, multidimensional databases (OLAP), data mining, time series, collaborative filtering, information retrieval

Simon Plouffe
Integer sequences, generalized expansions of real numbers

Xavier G. Viennot (Bordeaux 1)
Enumerative, algebraic, and bijective combinatorics, interactions between combinatorics, theoretical informatics, and theoretical physics

Mathematical Analysis

Description

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 2012–2013 the Laboratory included 28 regular and 10 associate members working at ten different universities in Canada, the United Kingdom, and France. The members of the Laboratory work in the following areas: harmonic analysis, complex analysis and 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.

News and highlights

As is typical for the Mathematical Analysis Laboratory, the year 2012–2013 featured many collaborative and training activities. Another activity was the highly successful "Workshop on Invariant Subspaces of the Shift Operator" (in August 2013). In Montréal the long-running Analysis Seminar is now taking place at different Montréal universities and has been renamed the "Montréal Analysis Seminar". French researchers Fricain, Pillet, and Panati visited the Laboratory and a group of five McGill students spent 6 weeks at the IHP in Paris and two weeks at a summer school in Autran. Y. Canzani, a 2013 Ph.D. from McGill supervised by D. Jakobson and J. Toth, is now a Benjamin Pierce Fellow at Harvard. The 2013 Carl Herz Prize was awarded to M. Najafi Ivaki, who obtained his Ph.D. at Concordia under the supervision of A. Stancu. In the 2012–2013 academic year 3 undergraduate students, 36 M.Sc. students, 39 Ph.D. students, and 19 postdoctoral fellows were supervised or cosupervised by members of the Mathematical Analysis Laboratory.

Members of the Laboratory

Regular members

Dmitry Jakobson (McGill), Director
Pure mathematics, global analysis, spectral geometry, quantum chaos, harmonic analysis, eigenvalues and eigenfunctions

Line Baribeau (Laval)
Complex and functional analysis, Banach algebras, holomorphic iterations, discrete groups

Abraham Boyarsky (Concordia)
Dynamical systems

Francis H. Clarke (Lyon 1)
Nonlinear and dynamic analysis, control theory, calculus of variations

Galia Dafni (Concordia)
Harmonic analysis, partial differential equations, complex variables

Donald A. Dawson (Carleton)
Probability, stochastic processes

S. W. Drury (McGill)
Harmonic analysis, matrix theory

Richard Fournier (Dawson)
Complex analysis, function theory

Marlène Frigon (Montréal)
Nonlinear analysis, differential equations, fixed point theory, critical point theory, multivalent analysis

Paul M. Gauthier (Montréal)
Complex analysis, holomorphy, harmonicity, analytic approximation

Pawel Gora (Concordia)
Ergodic theory, dynamical systems, fractal geometry

Frédéric Gourdeau (Laval)
Banach algebras, cohomology, amenability, functional analysis

Vojkan Jakšić (McGill)
Mathematical physics, quantum statistical mechanics, random Schrödinger operators

Tomasz Kaczynski (Sherbrooke)
Topological methods, Conley index, applications to dynamical systems

Ivo Klemes (McGill)
Harmonic analysis, trigonometric series

Alexey Kokotov (Concordia)
Spectral geometry of Riemann surfaces, hyperbolic partial differential equations

Paul Koosis (McGill)
Harmonic analysis

Javad Mashreghi (Laval)
Complex analysis, harmonic analysis, Hardy spaces

Iosif Polterovich (Montréal)
Geometric analysis, spectral theory, functional analysis, differential geometry, partial differential equations

Thomas J. Ransford (Laval)
Complex and harmonic analysis, functional analysis and theory of operators, spectral analysis, potential theory

Dominic Rochon (UQTR)
Complex analysis, hypercomplex numbers

Jérémie Rostand (Laval)
Complex analysis, experimental mathematics

Christiane Rousseau (Montréal)
Dynamical systems, bifurcations, qualitative theory, polynomial systems, analytic invariants, integrable systems

Dana Schlomiuk (Montréal)
Global analysis, dynamical systems, singularities, bifurcations, algebraic curves, primary integral

Robert Seiringer (McGill)
Many-body quantum systems, Bose-Einstein condensates

Alexander Shnirelman (Concordia)
Applications of geometric analysis to fluids and "weak" solutions of the Euler and Navier-Stokes equations

Alina Stancu (Concordia)
Geometric analysis

Ron J. Stern (Concordia)
Functional analysis and theory of operators, linear and nonlinear systems, non-smooth analysis, stability, optimal order

John A. Toth (McGill)
Spectral theory, semi-classical analysis, microlocal analysis, Hamiltonian mechanics

Associate members

Octavian Cornea (Montréal)
Algebraic topology, dynamical systems

Richard Duncan (Montréal)
Ergodic theory, martingale theory, probability theory in Banach spaces

Kohur Gowrisankaran (McGill)
Potential theory

Pengfei Guan (McGill)
Partial differential equations, geometric analysis, several complex variables

John Harnad (Concordia)
Mathematical physics, classical and quantum physics, geometrical methods, integrable systems, group theoretical methods, random matrices, isomonodromic deformations, isospectral flows

Niky Kamran (McGill)
Geometric approach to partial differential equations

Dmitry Korotkin (Concordia)
Integrable systems, isomonodromic deformations, classical and quantum gravity, Frobenius varieties

Nilima Nigam (Simon Fraser)
Applied analysis, numerical methods in electromagnetism

Yiannis N. Petridis (University College London)
Automorphic forms and their spectral theory, analytic number theory, spectral and scattering theory of manifolds

Samuel Zaidman (Montréal)
Functional analysis and differential equations in abstract spaces, pseudo-differential operators

Mathematical Physics

Description

The mathematical physics group is one of the oldest and most active at the CRM. It consists of 18 regular members, 10 local associate members, all full-time faculty members at one of the participating universities, and 7 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.

News and highlights

Two of the Laboratory members, J. Hurtubise and J. Walcher, were on the scientific committee of the 2012–2013 Thematic Year and organized the workshop "Moduli spaces and their invariants in mathematical physics." R. Brandenberger organized the workshop "Adventures in Superspace" in April 2013: its participants included nearly all the pioneers in supersymmetric field theory. Several prizes and distinctions were awarded to Laboratory members recently: L. Vinet was awarded the CAP–CRM Prize in 2012; R. Seiringer was awarded an NSERC E. W. R. Steacie Memorial Fellowship in 2012; J. Walcher was appointed to a Canada Research Chair (Tier II); and M. Grundland obtained a "Research fellowship" from the Digiteo Foundation. In the 2012–2013 academic year 10 undergraduate students, 29 M.Sc. students, 47 Ph.D. students, and 30 postdoctoral fellows were supervised or cosupervised by members of the Mathematical Physics Laboratory.

Members of the Laboratory

Regular members

John Harnad (Concordia), Director
Mathematical physics, classical and quantum physics, geometrical methods, integrable systems, group theoretical methods, random matrices, isomonodromic deformations, isospectral flows

S. Twareque Ali (Concordia)
Coherent states, wavelets, quantization techniques, harmonic analysis, Wigner functions

Marco Bertola (Concordia)
Axiomatic quantum field theory, invariant theory of discrete groups, random matrices, isomonodromic deformations

Robert Brandenberger (McGill)
Theoretical Cosmology

Keshav Dasgupta (McGill)
Heavy ion collision theory in the energy range 30MeV/nucleon to many GeV/nucleon

Alfred Michel Grundland (UQTR)
Symmetry of differential equations in physics

Richard L. Hall (Concordia)
Spectra of Schrödinger, Klein-Gordon, Dirac, and Salpeter operators, many-body problems, relativistic scattering theory, iterative solution to ODEs and boundary-value problems

Jacques Hurtubise (McGill)
Algebraic geometry, integrable systems, gauge theory, moduli spaces

Véronique Hussin (Montréal)
Group theory, Lie algebras and applications in physics, supersymmetries in classical and quantum mechanics

Dmitry Korotkin (Concordia)
Integrable systems, isomonodromic deformations, classical and quantum gravity, Frobenius varieties

Pierre Mathieu (Laval)
Conformal field theory, classical and quantum integrable systems, affine Lie algebras

Manu Paranjape (Montréal)
Theoretical particle physics: field theory, solitons, noncommutative geometry, alternative gravity

Jiří Patera (Montréal)
Applications of group theory, quasi-crystals, Lie algebras

Yvan Saint-Aubin (Montréal)
Conformal field theory, statistical mechanics, 2-dimensional phase transition model

Robert Seiringer (McGill)
Quantum many-body systems, Bose-Einstein condensates, Ginzburg-Landau theory, Gross-Pitaevskii theory, bosons

Vasilisa Shramchenko (Sherbrooke)
Frobenius manifolds, integrable systems, Riemann-Hilbert problems, isomonodromic deformations of systems of linear differential equations, function theory on Riemann surfaces

Luc Vinet (Montréal)
Symmetry properties of systems, special functions

Johannes Walcher (McGill)
Mirror symmetry for open strings, non-geometric string compactifications

Pavel Winternitz (Montréal)
Methods of group theory in physics, nonlinear phenomena, symmetries of difference equations, superintegrability

Associate members

Robert Conte (CEA/Saclay)
Integrable and partially integrable systems, Painlevé analysis, exact solutions, finite difference equations

Chris Cummins (Concordia)
Group theory, modular functions, moonshine

Stéphane Durand (Édouard-Montpetit)
Classical and quantum physics, mathematical physics, symmetries, parasupersymmetries, fractional supersymmetries, KdV equations, quantum mechanics, relativity

Bertrand Eynard (CEA/Saclay)
Matrix models, integrable systems, string theory, relationship between matrix models, integrability, and algebraic geometry

Jean-Pierre Gazeau (Paris Diderot)
Coherent states, wavelets, relativistic quantum frames, symmetry groups for beta-lattices

Alexander Its (IUPUI)
Soliton theory, integrable systems, special functions, mathematical physics

Dmitry Jakobson (McGill)
Pure mathematics, global analysis, spectral geometry, quantum chaos, harmonic analysis, eigenvalues and eigenfunctions

Vojkan Jakšić (McGill)
Mathematical physics, quantum statistical mechanics, random Schrödinger operators

Niky Kamran (McGill)
Geometric approach to partial differential equations

François Lalonde (Montréal)
Symplectic topology and geometry, global analysis on manifolds, Hamiltonian systems

Decio Levi (Roma Tre)
Symmetries of differential and difference equations, integrable nonlinear equations on the lattice and reductive perturbation theory on the lattice

Alexander Maloney (McGill)
String theory, particle physics, cosmology, quantum gravity

Alexander Shnirelman (Concordia)
Applications of geometrical analysis to fluids and "weak" solutions of the Euler and Navier-Stokes equations

John A. Toth (McGill)
Spectral theory, semi-classical analysis, microlocal analysis, Hamiltonian mechanics

Alexander Turbiner (UNAM, Mexico)
Quantum mechanics, atomic and molecular physics, variational methods

Carolyne M. Van Vliet (Montréal & Miami)
Non-equilibrium statistical mechanics, fluctuations and stochastic processes, quantum transport in condensed matter, electronic behaviour in submicron quantum devices

Peter Zograf (Steklov Mathematical Institute, St. Petersburg)
Geometry of moduli spaces, automorphic forms, spectral geometry

PhysNum

Description

Applied mathematics now plays an important role in the biomedical field and especially the neurosciences. The research activity at PhysNum has two main themes: pharmacometrics and brain imaging. In particular

- Jean-Marc Lina (École de technologie supérieure) and Habib Benali (Université Pierre et Marie Curie) work on the multimodal imaging of the spinal cord;
- Lina and Christophe Grova (McGill University) work on multiresolution and multimodal imaging in magneto-electrophysiology;
- Benali and Maxime Descoteaux (Université de Sherbrooke) study models of the anatomical and functional connectivity of the brain;
- Grova studies neurovascular models in epilepsy;
- Lina studies sparse representations, inverse problems, and brain wave synchronization; and
- Lina analyzes 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 in terms of efficacy and bioequivalence; revisiting classical concepts in pharmacology and updating their formulation; developing models for drug interactions; integrating physiology with behaviour to create a real fingerprint of drugs; integrating advanced hematopoietic models with PK/PD to improve concurrent therapy consisting of oncological drugs and their adjuvants.

News and highlights

In October 2013 Ciuciu and Lina prepared a workshop held in October 2013, the Workshop on Scale-free Dynamics and Networks in Neurosciences. PhysNum partners with the Athena team within INRIA (Sophia-Antipolis, France) and an international laboratory, LINeM, within INSERM (the French Health Research Institute). In the 2012–2013 academic year 18 M.Sc. students, 25 Ph.D. students, and 8 postdoctoral fellows were supervised or cosupervised by PhysNum members.

Members of the Laboratory

Regular members

Jean-Marc Lina (ÉTS), Director
Wavelets, statistical modelling and brain imaging, machine learning

Alain Arnéodo (ÉNS Lyon & CNRS)
Fractals and wavelets

Habib Benali (UPMC)
Quantitative analysis in brain imaging, medical imaging and multimodal systems

Maxime Descoteaux (Sherbrooke)
Medical imaging, image analysis and processing, computer vision, applied mathematics

Christophe Grova (McGill)
Statistical signal processing, localization of epileptic spikes using distributed sources modelling, and multimodal analysis of EEG source localization and simultaneous EEG-fMRI data analysis

Frédéric Lesage (Polytechnique Montréal)
Conformal theory, integrable systems, inverse problems, optical imaging

Fahima Nekka (Montréal)
Pharmacokinetics, development of mathematical tools from fractal geometry and harmonic analysis for extracting information, applications to pharmacology and medicine

Statistics

Description

Statistics is central to many endeavours in society. Be it through surveys from sampling, clinical trials to study various biomedical treatments, or experimental designs in agriculture or industry, 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. For example, statistical methodology is now addressing problems whose structure is very complex, such as the analysis of brain images or genome data, and new methodology is being developed, such as data mining, 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.

News and highlights

Nowadays the analysis of unimaginably vast amounts of data poses significant challenges, both methodologically and in terms of HQP training. The Laboratory contributes to this effort through an average of 150 scientific publications per year and extensive graduate supervision. This year 130 M.Sc. and 86 Ph.D. students were supervised or co-supervised by Laboratory members; those who completed their studies found immediate employment after their studies. Of the 10 PDFs, four found tenure-track positions in Canada while the six others are still in training. The CRM provided financial support for the Montreal Spring School of "Population Genomics and Genetic Epidemiology" (May 2013), the "3rd Graduate Student Workshop on Actuarial and Financial Mathematics" (December 2013), and the "Concordia Workshop on Nonparametric Curve Smoothing" (December 2013).

Members of the Laboratory

Regular members

Louis-Paul Rivest (Laval), Director
Linear models, robustness, directional data, sampling, applications in finance

Belkacem Abdous (Laval)
Biostatistics, health research methodology, construction and validation of measuring tools in the health sector

Jean-François Angers (Montréal)
Decision theory, Bayesian statistics, robustness with respect to prior information, function estimation

Masoud Asgharian (McGill)
Survival analysis, change-point problems, simulated annealing and its variants, optimization

Yoshua Bengio (Montréal)
Statistical learning algorithms, neural networks, nucleus models, probabilistic models, data mining, applications in finance and statistical language modelling

Martin Bilodeau (Montréal)
Multivariate analysis, decision theory, asymptotic methods

Yogendra P. Chaubey (Concordia)
Sampling, linear models, resampling, survival analysis

Pierre Duchesne (Montréal)
Time series, sampling, multivariate analysis

Thierry Duchesne (Laval)
Survival analysis, longitudinal data analysis, missing data, modelling of losses, insurance of catastrophic incidents, nonparametric inference, model selection, warranty

Debbie J. Dupuis (HEC Montréal)
Extreme values, robustness

Sorana Froda (UQAM)
Nonparametric methods in function estimation, applications of stochastic modelling in biology and medicine

Christian Genest (McGill)
Multidimensional data analysis, dependence measures,

nonparametric statistics, decision theory, applications in actuarial science, finance, and psychology

Nadia Ghazzali (Laval)
Multidimensional data analysis, neural networks and genetic algorithms, applications in astrophysics and biostatistics

Aurélie Labbe (McGill)
Biostatistics and statistical genetics

Fabrice Larribe (UQAM)
Statistical genetics and biostatistics

Christian Léger (Montréal)
Resampling methods, adaptive estimation, model selection, robustness, applications in data mining

Brenda MacGibbon (UQAM)
Mathematical statistics, decision theory, biostatistics

Éric Marchand (Sherbrooke)
Statistical inference, Bayesian statistics, multivariate analysis and probability

Alejandro Murua (Montréal)
Data mining, machine learning, object recognition, signal processing, and various applications of statistics and probability to bioinformatics and the social and health sciences

François Perron (Montréal)
Decision theory, multidimensional data analysis, Bayesian statistics

James Ramsay (McGill)
Functional data analysis, smoothing and nonparametric regression, curve registration

Bruno Rémillard (HEC Montréal)
Probability theory, empirical processes, time series, nonlinear filtering, applications in finance

Roch Roy (Montréal)
Time series analysis, predictive methods, applications in econometrics and epidemiology

Arusharka Sen (Concordia)
Statistical inference of truncated data, nonparametric function estimation

Russell Steele (McGill)
Bayesian approaches to mixing modelling, multiple imputation

David Stephens (McGill)
Bayesian statistics, Markov Chain Monte Carlo and applications to bioinformatics, statistical genetics, and time series analysis

Wei Sun (Concordia)
Nonlinear filtering and its applications, stochastic analysis, statistical inference, stochastic modelling

David B. Wolfson (McGill)
Change-point problems, survival analysis, Bayesian statistics, optimal design, applications in medicine

Associate members

Juli Atherton (McGill)
Biostatistics, optimal Bayesian design, change-point problems, survival analysis, applications to genetics

Mylène Bédard (Montréal)
Optimal scaling, Metropolis-Hastings algorithms

Anne-Catherine Favre (Laval)
Statistical hydrology, analysis and modelling of time series

José Garrido (Concordia)
Risk theory, insurance statistics

David Haziza (Montréal)
Sampling theory, inference with missing data, robust inference

Lajmi Lakhal Chaïeb (Laval)
Multidimensional analysis of survival data, analysis of recurrent events, semi-parametric models and incomplete data

Geneviève Lefebvre (UQAM)
Bayesian and computational statistics, biostatistics

Erica E. M. Moodie (McGill)
Causal inference, optimal dynamic treatment regimes, longitudinal data, dose-response relationships

Manuel Morales (Montréal)
Mathematical finance, applied stochastic processes, ruin theory, actuarial science, Lévy processes, mathematics of insurance

Johanna Nešlehová (McGill)
Multivariate analysis, dependence modelling, nonparametric and asymptotic statistics, multivariate extreme value theory, empirical processes, applications to biostatistics, neuroscience and risk management

Robert W. Platt (McGill)
Biostatistics and statistical methods for pediatric and perinatal epidemiology.

Lea Popovic (Concordia)
Probability theory and its applications to evolutionary biology, population genetics, and cell biology

Publications

The CRM publishes monographs, lecture notes, proceedings, software, videos, and research reports. It has several collections. The in-house collection (Les Publications CRM) offers titles in both English and French. The CRM also has publishing agreements with the American Mathematical Society (AMS) and Springer. Since 1992, two collections, edited by the CRM, have been published and distributed by the AMS. They are the *CRM Monograph Series* and the *CRM Proceedings and Lecture Notes*. Springer publishes the *CRM Series in Mathematical Physics*. An asterisk preceding a publication indicates that its author is an Aisenstadt Chairholder.

Recent Titles

The following list of recent titles contains books that appeared in 2012–2013 or that will be published soon.

American Mathematical Society CRM Monograph Series

Libor Šnobl & Pavel Winternitz, *Classification and Identification of Lie Algebras*, to appear

Pavel Bleher & Karl Liechty, *Random Matrices and the Six-Vertex Model*, to appear.

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

American Mathematical Society CRM Proceedings & Lecture Notes

Galia Dafni, Robert John McCann & Alina Stancu (eds.), *Analysis and Geometry of Metric Measure Spaces*: *Lecture Notes of the* 50*th Séminaire de Mathématiques Supérieures* (*SMS*), *Montréal*, 2011, vol. 56, 2013.

André Boivin & Javad Mashreghi (eds.), *Complex Analysis and Potential Theory*, vol. 55, 2012.

American Mathematical Society Contemporary Mathematics (Centre de Recherches Mathématiques Proceedings)

Chantal David, Matilde Lalín & Michelle Manes (eds.), *Women in Numbers* 2: *Research Directions in Number Theory*, to appear.

Omid Amini, Matthew Baker & Xander Faber (eds.), *Tropical and Non-Archimedean Geometry*, to appear.

Previous Titles

American Mathematical Society CRM Monograph Series

Joseph H. Silverman, *Moduli Spaces and Arithmetic Dynamics*, vol 30, 2012.

Marcelo Aguiar & Swapneel Mahajan, *Monoidal Categories, Species and Hopf Algebras*, vol 29, 2010.

Saugata Ghosh, *Skew-Orthogonal Polynomials and Random Matrix Theory*, vol. 28, 2009.

Jean Berstel, Aaron Lauve, Christophe Reutenauer & Franco V. Saliola, *Combinatorics on Words*: *Christoffel Words and Repetitions in Words*, vol. 27, 2008.

Victor Guillemin & Reyer Sjamaar, *Convexity Properties of Hamiltonian Group Actions*, vol. 26, 2005.

*Andrew J. Majda, Rafail V. Abramov & Marcus J. Grote, *Information Theory and Stochastics for Multiscale Nonlinear Systems*, vol. 25, 2005.

Dana Schlomiuk, Andrei A. Bolibrukh, Sergei Yakovenko, Vadim Kaloshin & Alexandru Buium, *On Finiteness in Differential Equations and Diophantine Geometry*, vol. 24, 2005.

Prakash Panangaden & Franck van Breugel (eds.), *Mathematical Techniques for Analyzing Concurrent and Probabilistic Systems*, vol. 23, 2004.

Montserrat Alsina & Pilar Bayer, *Quaternion Orders, Quadratic Forms, and Shimura Curves*, vol. 22, 2004.

Andrei Tyurin, *Quantization, Classical and Quantum Field Theory and Theta Functions*, vol. 21, 2003.

Joel Feldman, Horst Knörrer & Eugene Trubowitz, *Riemann Surfaces of Infinite Genus*, vol. 20, 2003.

*Laurent Lafforgue, *Chirurgie des grassmanniennes*, vol. 19, 2003.

*George Lusztig, *Hecke Algebras with Unequal Parameters*, vol. 18, 2003.

Michael Barr, *Acyclic Models*, vol. 17, 2002.

*Joel Feldman, Horst Knörrer & Eugene Trubowitz, *Fermionic Functional Integrals and the Renormalization Group*, vol. 16, 2002.

Jose I. Burgos, *The Regulators of Beilinson and Borel*, vol. 15, 2002.

Eyal Z. Goren, *Lectures on Hilbert Modular Varieties and Modular Forms*, vol. 14, 2002.

Michael Baake & Robert V. Moody (eds.), *Directions in Mathematical Quasicrystals*, vol. 13, 2000.

Masayoshi Miyanishi, *Open Algebraic Surfaces*, vol. 12, 2001.

Spencer J. Bloch, *Higher Regulators, Algebraic K-Theory, and Zeta Functions of Elliptic Curves*, vol. 11, 2000.

James D. Lewis, *A Survey of the Hodge Conjecture*, 2nd edition, vol. 10, 1999 (with an appendix from B. Brent Gordon).

*Yves Meyer, *Wavelets, Vibrations and Scaling*, vol. 9, 1997.

*Ioannis Karatzas, *Lectures on Mathematics of Finance*, vol. 8, 1996.

John Milton, *Dynamics of Small Neural Populations*, vol. 7, 1996.

*Eugene B. Dynkin, *An Introduction to Branching Measure-Valued Processes*, vol. 6, 1994.

Andrew M. Bruckner, *Differentiation of Real Functions*, vol. 5, 1994.

*David Ruelle, *Dynamical Zeta Functions for Piecewise Monotone Maps of the Interval*, vol. 4, 1994.

V. Kumar Murty, *Introduction to Abelian Varieties*, vol. 3, 1993.

Maximilian Ya. Antimirov, Andrei A. Kolyshkin & Rémi Vaillancourt, *Applied Integral Transforms*, vol. 2, 1993.

*Dan V. Voiculescu, Kenneth J. Dykema & Alexandru Nica, *Free Random Variables*, vol. 1, 1992.

American Mathematical Society CRM Proceedings & Lecture Notes

Daniel Daigle, Richard Ganong & Mariusz Koras (eds.), *Affine Algebraic Geometry: The Russell Festschrift*, vol. 54, 2011.

Bradd Hart, Thomas G. Kucera, Anand Pillay, Philip J. Scott & Robert A. G. Seely (eds.), *Models, Logics, and Higher-Dimensional Categories*, vol. 53, 2011.

Dmitry Jakobson, Stéphane Nonnenmacher & Iosif Polterovich (eds.), *Spectrum and Dynamics*, vol. 52, 2010.

Javad Mashreghi, Thomas Ransford & Kristian Siep (eds.), *Hilbert Spaces of Analytic Functions*, vol. 51, 2010.

P. Robert Kotiuga (ed.), *A Celebration of the Mathematical Legacy of Raoul Bott*, vol. 50, 2009.

Miguel Abreu, François Lalonde & Leonid Polterovich (eds.), *New Perspectives and Challenges in Symplectic Field Theory*, vol. 49, 2009.

David Avis, David Bremner & Antoine Deza (eds.), *Polyhedral Computation*, vol. 48, 2009.

John Harnad & Pavel Winternitz (eds.), *Groups and Symmetries: From Neolithic Scots to John McKay*, vol. 47, 2009.

Jean-Marie De Koninck, Andrew Granville & Florian Luca (eds.), *Anatomy of Integers*, vol. 46, 2008.

Panos M. Pardalos & Pierre Hansen (eds.), *Data Mining and Mathematical Programming*, vol. 45, 2008.

Stanley Alama, Lia Bronsard & Peter Sternberg (eds.), *Singularities in PDE and the Calculus of Variations*, vol. 44, 2007.

Andrew Granville, Melvyn B. Nathanson & Jozsef Solymosi (eds.), *Additive Combinatorics*, vol. 43, 2007.

Donald A. Dawson, Vojkan Jakšić & Boris Vainberg (eds.), *Probability and Mathematical Physics: A Volume in Honor of Stanislav Molchanov*, vol. 42, 2007.

André Bandrauk, Michel C. Delfour & Claude Le Bris (eds.), *High-Dimensional Partial Differential Equations in Science and Engineering*, vol. 41, 2007.

Vestislav Apostolov, Andrew Dancer, Nigel Hitchin & McKenzie Wang (eds.), *Perspectives in Comparison, Generalized and Special Geometry*, vol. 40, 2006.

Pavel Winternitz, David Gomez-Ullate, Arieh Iserles, Decio Levi, Peter J. Olver, Reinout Quispel & Piergiulio Tempesta (eds.), *Group Theory and Numerical Analysis*, vol. 39, 2005.

Jacques Hurtubise & Eyal Markman (eds.), *Algebraic Structures and Moduli Spaces*, vol. 38, 2004.

Piergiulio Tempesta, Pavel Winternitz, John Harnad, Willard Miller Jr., George Pogosyan & Miguel A. Rodriguez (eds.), *Superintegrability in Classical and Quantum Systems*, vol. 37, 2004.

Hershy Kisilevsky & Eyal Z. Goren (eds.), *Number Theory*, vol. 36, 2004.

H. E. A. Eddy Campbell & David L. Wehlau (eds.), *Invariant Theory in All Characteristics*, vol. 35, 2004.

Pavel Winternitz, John Harnad, C. S. Lam & Jiří Patera (eds.), *Symmetry in Physics*, vol. 34, 2004.

André D. Bandrauk, Michel C. Delfour & Claude Le Bris (eds.), *Quantum Control: Mathematical and Numerical Challenges*, vol. 33, 2003.

Vadim B. Kuznetsov (ed.), *The Kowalevski Property*, vol. 32, 2002.

John Harnad & Alexander R. Its (eds.), *Isomonodromic Deformations and Applications in Physics*, vol. 31, 2002.

John McKay & Abdellah Sebbar (eds.), *Proceedings on Moonshine and Related Topics*, vol. 30, 2001.

Alan Coley, Decio Levi, Robert Milson, Colin Rogers & Pavel Winternitz (eds.), *Bäcklund and Darboux Transformations*, vol. 29, 2001.

John C. Taylor (ed.), *Topics in Probability and Lie Groups: Boundary Theory*, vol. 28, 2001.

Israel M. Sigal & Catherine Sulem (eds.), *Nonlinear Dynamics and Renormalization Group*, vol. 27, 2001.

John Harnad, Gert Sabidussi & Pavel Winternitz (eds.), *Integrable Systems: From Classical to Quantum*, vol. 26, 2000.

Decio Levi & Orlando Ragnisco (eds.), *SIDE* III—*Symmetry and Integrability of Difference Equations*, vol. 25, 2000.

B. Brent Gordon, James D. Lewis, Stefan Müller-Stach, Shuji Saito & Noriko Yui (eds.), *The Arithmetic and Geometry of Algebraic Cycles*, vol. 24, 2000.

Pierre Hansen & Odile Marcotte (eds.), *Graph Colouring and Applications*, vol. 23, 1999.

Jan Felipe van Diejen & Luc Vinet (eds.), *Algebraic Methods and q-Special Functions*, vol. 22, 1999.

Michel Fortin (ed.), *Plates and Shells*, vol. 21, 1999.

Katie Coughlin (ed.), *Semi-Analytic Methods for the Navier–Stokes Equations*, vol. 20, 1999.

Rajiv Gupta & Kenneth S. Williams (eds.), *Number Theory*, vol. 19, 1999.

Serge Dubuc & Gilles Deslauriers (eds.), *Spline Functions and the Theory of Wavelets*, vol. 18, 1999.

Olga Kharlampovich (ed.), *Summer School in Group Theory in Banff,* 1996, vol. 17, 1998.

Alain Vincent (ed.), *Numerical Methods in Fluid Mechanics*, vol. 16, 1998.

François Lalonde (ed.), *Geometry, Topology and Dynamics*, vol. 15, 1998.

John Harnad & Alex Kasman (eds.), *The Bispectral Problem*, vol. 14, 1998.

Michel Delfour (ed.), *Boundaries, Interfaces and Transitions*, vol. 13, 1998.

Peter G. Greiner, Victor Ivrii, Luis A. Seco & Catherine Sulem (eds.), *Partial Differential Equations and their Applications*, vol. 12, 1997.

Luc Vinet (ed.), *Advances in Mathematical Sciences: CRM's 25 Years*, vol. 11, 1997.

Donald E. Knuth, *Stable Marriage and Its Relation to Other Combinatorial Problems*, vol. 10, 1996.

Decio Levi, Luc Vinet & Pavel Winternitz (eds.), *Symmetries and Integrability of Difference Equations*, vol. 9, 1995.

Joel S. Feldman, Richard Froese & Lon M. Rosen (eds.), *Mathematical Quantum Theory* II: *Schrödinger Operator*, vol. 8, 1995.

Joel S. Feldman, Richard Froese & Lon M. Rosen (eds.), *Mathematical Quantum Theory* I: *Field Theory and Many-Body Theory*, vol. 7, 1994.

Guido Mislin (ed.), *The Hilton Symposium* 1993, vol. 6, 1994.

Donald A. Dawson (ed.), *Measure-Valued Processes, Stochastic Partial Differential Equations and Interacting Systems*, vol. 5, 1994.

Hershy Kisilevsky & M. Ram Murty (eds.), *Elliptic Curves and Related Topics*, vol. 4, 1994.

Andrei L. Smirnov & Rémi Vaillancourt (eds.), *Asymptotic Methods in Mechanics*, vol. 3, 1993.

Philip D. Loewen, *Optimal Control via Nonsmooth Analysis*, vol. 2, 1993.

M. Ram Murty (ed.), *Theta Functions*, vol. 1, 1993.

Springer
CRM Series in Mathematical Physics

André D. Bandrauk & Misha Ivanov (eds.), *Quantum Dynamic Imaging*, 2011.

John Harnad (ed.), *Random Matrices, Random Processes and Integrable Systems*, 2011.

Marc Thiriet, *Biology and Mechanics of Blood Flows*, 2008 (2 volumes).

David Sénéchal, André-Marie Tremblay & Claude Bourbonnais (eds.), *Theoretical Methods for Strongly Correlated Electrons*, 2003.

*Roman Jackiw, *Lectures on Fluid Dynamics*, 2002.

Yvan Saint-Aubin & Luc Vinet (eds.), *Theoretical Physics at the End of the Twentieth Century*, 2001.

Yvan Saint-Aubin & Luc Vinet (eds.), *Algebraic Methods in Physics*, 2000.

Jan Felipe van Diejen & Luc Vinet (eds.), *Calogero–Moser–Sutherland Models*, 1999.

Robert Conte (ed.), *The Painlevé Property*, 1999.

Richard MacKenzie, Manu B. Paranjape & Wojciech J. M. Zakrzewski (eds.), *Solitons*, 1999.

Luc Vinet & Gordon Semenoff (eds.), *Particles and Fields*, 1998.

Séminaires de mathématiques supérieures

Vašek Chvátal (ed.), *Combinatorial Optimization: Methods and Applications*, NATO Science for Peace and Security Series - D: Information and Communication Security, vol. 31, IOS Press, 2011.

Decio Levi, Peter Olver, Zora Thomova & Pavel Winternitz (eds.), *Symmetries and Integrability of Difference Equations*, London Mathematical Society Lecture Note Series, vol. 381, Cambridge University Press, 2011.

Springer
Lecture Notes in Statistics (subseries CRM)

Marc Moore (ed.), *Spatial Statistics: Methodological Aspects and Applications*, vol. 159, 2001.

S. Ejaz Ahmed & Nancy Reid (eds.), *Empirical Bayes and Likelihood Inference*, vol. 148, 2001.

Les Publications CRM

Laurent Guieu & Claude Roger, *L'Algèbre et le Groupe de Virasoro*, 2007.

Luc Lapointe, Ge Mo-Lin, Yvan Saint-Aubin & Luc Vinet, *Proceedings of the Canada–China Meeting on Theoretical Physics*, 2003.

Armel Mercier, *Fonctions de plusieurs variables : Différentiation*, 2002.

Nadia El-Mabrouk, Thomas Lengauer & David Sankoff (eds.), *Currents in Computational Molecular Biology*, 2001.

James G. Huard & Kenneth S. Williams (eds.), *The Collected Papers of Sarvadaman Chowla*. Volume I: 1925–1935; Volume II: 1936–1961; Volume III: 1962–1986, 2000.

Michael Barr & Charles Wells, *Category Theory for Computing Science*, 1999.

Maximilian Ya. Antimirov, Andrei A. Kolyshkin & Rémi Vaillancourt, *Mathematical Models for Eddy Current Testing*, 1998.

Xavier Fernique, *Fonctions aléatoires gaussiennes, vecteurs aléatoires gaussiens*, 1997.

Faqir Khanna & Luc Vinet (eds.), *Field Theory, Integrable Systems and Symmetries*, 1997.

Paul Koosis, *Leçons sur le théorème de Beurling et Malliavin*, 1996.

David W. Rand, *Concorder Version Three*, 1996 (software and user guide).

Jacques Gauvin, *Theory of Nonconvex Programming*, 1994.

Decio Levi, Curtis R. Menyuk & Pavel Winternitz (eds.), *Self-Similarity in Stimulated Raman Scattering*, 1994.

Rémi Vaillancourt, *Compléments de mathématiques pour ingénieurs*, 1993.

Robert P. Langlands & Dinakar Ramakrishnan (eds.), *The Zeta Functions of Picard Modular Surfaces*, 1992.

Florin N. Diacu, *Singularities of the N-Body Problem*, 1992.

Jacques Gauvin, *Théorie de la programmation mathématique non convexe*, 1992.

Pierre Ferland, Claude Tricot & Axel van de Walle, *Analyse fractale*, 1992 (software and user guide).

Stéphane Baldo, *Introduction à la topologie des ensembles fractals*, 1991.

Robert Bédard, *Groupes linéaires algébriques*, 1991.

Rudolf Beran & Gilles R. Ducharme, *Asymptotic Theory for Bootstrap Methods in Statistics*, 1991.

James D. Lewis, *A Survey of the Hodge Conjecture*, 1991.

David W. Rand & Tatiana Patera, *Concorder*, 1991 (software and user guide).

David W. Rand & Tatiana Patera, *Le Concordeur*, 1991 (software and user guide).

Véronique Hussin (ed.), *Lie Theory, Differential Equations and Representation Theory*, 1990.

John Harnad & Jerrold E. Marsden (eds.), *Hamiltonian Systems, Transformation Groups and Spectral Transform Methods*, 1990.

M. Ram Murty (ed.), *Automorphic Forms and Analytic Number Theory*, 1990.

Wendy G. McKay, Jiří Patera & David W. Rand, *Tables of Representations of Simple Lie Algebras.* Volume I*: Exceptional Simple Lie Algebras*, 1990.

Anthony W. Knapp, *Representations of Real Reductive Groups*, 1990.

Wendy G. McKay, Jiří Patera & David W. Rand, *SimpLie*, 1990 (software and user guide).

Francis H. Clarke, *Optimization and Nonsmooth Analysis*, Montréal, 1989.

Samuel Zaidman, *Une Introduction à la théorie des équations aux dérivées partielles*, 1989.

*Yuri I. Manin, *Quantum Groups and Noncommutative Geometry*, 1988.

Lucien Le Cam, *Notes on Asymptotic Methods in Statistical Decision Theory*, 1974.

Les Presses de l'Université de Montréal Chaire Aisenstadt

*Laurent Schwartz, *Semimartingales and their Stochastic Calculus on Manifolds*, 1984.

*Yuval Ne′eman, *Symétries, jauges et variétés de groupe*, 1979.

*R. Tyrrell Rockafellar, *La théorie des sous-gradients et ses applications à l'optimisation, fonctions convexes et non convexes*, 1979.

*Jacques-Louis Lions, *Sur quelques questions d'analyse, de mécanique et de contrôle optimal*, 1976.

*Donald E. Knuth, *Mariages stables et leurs relations avec d'autres problèmes combinatoires*, 1976.

*Robert Hermann, *Physical Aspects of Lie Group Theory*, 1974.

*Mark Kac, *Quelques problèmes mathématiques en physique statistique*, 1974.

*Sybreen de Groot, *La transformation de Weyl et la fonction de Wigner : une forme alternative de la mécanique quantique*, 1974.

Other Collaborations with Publishers

Marc Moore, Sorana Froda & Christian Léger (eds.), *Mathematical Statistics and Applications: Festschrift for Constance van Eeden*, Lecture Notes–Monograph Series, vol. 42, 2003 (a collaboration with the Institute of Mathematical Statistics).

Duong H. Phong, Luc Vinet & Shing-Tung Yau (eds.), *Mirror Manifolds and Geometry*, AMS/IP Studies in Advanced Mathematics, vol. 10, 1998 (a collaboration with the AMS and International Press).

Pierre Ferland, Claude Tricot & Axel van de Walle, *Fractal Analysis User's Guide*, 1994 (a collaboration with the AMS).

Hedy Attouch, Jean-Pierre Aubin, Francis Clarke & Ivar Ekeland (eds.), *Analyse non linéaire*, 1989 (a collaboration with Gauthier-Villars).

Videos

Efim Zelmanov, *Abstract Algebra in the 20th Century*, 1997.

Serge Lang, *Les grands courants*, 1991.

Robert Bédard, *Brouiller les cartes*, 1991.

Serge Lang, *Les équations diophantiennes*, 1991.

Laurent Schwartz, *Le mouvement brownien*, 1990.

Laurent Schwartz, *Une vie de mathématicien*, 1989.

Scientific Personnel

CRM Members in 2012–2013

In contrast with most other mathematics institutes around the world, the CRM can count on the solid foundation of regular, associate, and invited members. Most regular members are also professors at one of the partner institutions: Montréal, Concordia, McGill, UQAM, Laval, Sherbrooke, and Ottawa. Other members are researchers affiliated with the CRM in 2012–2013 as part of exchange agreements with neighbouring universities and industry or are long-term visitors from Canadian and foreign institutions. The presence at the CRM of such an active group of researchers has brought many benefits to the Centre. In particular, the national program of the CRM is greatly facilitated by having on hand a large reserve of willing organizers, who even contribute financially to the organization of activities. The largest partnership is with the Université de Montréal, which grants the equivalent of five full-time teaching positions in release time to the CRM. Release agreements with the other Montréal area universities afford the equivalent of two more full-time positions to the CRM. Facilities are also provided to researchers affiliated with junior colleges. Several members are affiliated with the CRM through industrial agreements.

Regular members

Louigi Addario-Berry, McGill
Syed Twareque Ali, Concordia
Jean-François Angers, Montréal
Vestislav Apostolov, UQAM
Ibrahim Assem, Sherbrooke
André D. Bandrauk, Sherbrooke
Line Baribeau, Laval
Peter Bartello, McGill
Robert Bédard, UQAM
Jacques Bélair, Montréal
Habib Benali, UPMC & Inserm
Yoshua Bengio, Montréal
François Bergeron, UQAM
Marco Bertola, Concordia
Yves Bourgault, Ottawa
Anne Bourlioux, Montréal
Steven P. Boyer, UQAM
Gilles Brassard, Montréal
Srečko Brlek, UQAM
Thomas Brüstle, Sherbrooke & Bishop's
Virginie Charette, Sherbrooke
Cédric Chauve, Simon Fraser
Vašek Chvátal, Concordia
Rustum Choksi, McGill
Francis H. Clarke, Lyon 1
Olivier Collin, UQAM
Octav Cornea, Montréal
Miklós Csűrös, Montréal
Chris J. Cummins, Concordia
Galia Dafni, Concordia
Henri Darmon, McGill
Chantal David, Concordia
Jean-Marie De Koninck, Laval
Michel C. Delfour, Montréal
Maxime Descoteaux, Sherbrooke
Eusebius J. Doedel, Concordia
Pierre Duchesne, Montréal
Thierry Duchesne, Laval
Nadia El-Mabrouk, Montréal
André Fortin, Laval
Richard Fournier, Dawson & Montréal
Marlène Frigon, Montréal
André Garon, Polytechnique Montréal
Paul M. Gauthier, Montréal
Christian Genest, McGill
Eyal Z. Goren, McGill
Andrew Granville, Montréal
Christophe Grova, McGill
Alfred Michel Grundland, UQTR
Pengfei Guan, McGill
Geňa Hahn, Montréal
Richard L. Hall, Concordia
Sylvie Hamel, Montréal
John Harnad, Concordia
Tony R. Humphries, McGill

Jacques Hurtubise, McGill
Véronique Hussin, Montréal
Adrian Iovita, Concordia
Dmitry Jakobson, McGill
Vojkan Jakšić, McGill
Tomasz Kaczynski, Sherbrooke
Niky Kamran, McGill
Olga Kharlampovich, McGill
Hershy Kisilevsky, Concordia
Paul Koosis, McGill
Dmitry Korotkin, Concordia
Gilbert Labelle, UQAM
John Labute, McGill
Matilde Lalín, Montréal
François Lalonde, Montréal
Benoît Larose, Champlain St-Lambert & Concordia
Michael Lau, Laval
Christian Léger, Montréal
Frédéric Lesage, Polytechnique Montréal
Jean-Philippe Lessard, Laval
Sabin Lessard, Montréal
Claude Levesque, Laval
Jean-Marc Lina, ÉTS
Shiping Liu, Sherbrooke
Emmanuel Lorin de la Grandmaison, Carleton
Steven Lu, UQAM
Brenda MacGibbon, UQAM
Michael C. Mackey, McGill
Vladimir Makarenkov, UQAM
Michael Makkai, McGill
Javad Mashreghi, Laval
Sherwin A. Maslowe, McGill
Pierre Mathieu, Laval
John McKay, Concordia
Manuel Morales, Montréal
M. Ram Murty, Queen's
Fahima Nekka, Montréal
Adam M. Oberman, McGill
Robert G. Owens, Montréal
Manu Paranjape, Montréal
Jiří Patera, Montréal
François Perron, Montréal
Mikaël Pichot, McGill
Iosif Polterovich, Montréal
Lea Popovic, Concordia
James O. Ramsay, McGill
Thomas J. Ransford, Laval
Bruno Rémillard, HEC Montréal
Christophe Reutenauer, UQAM
Louis-Paul Rivest, Laval
Frédéric Rochon, UQAM
Ivo G. Rosenberg, Montréal
Christiane Rousseau, Montréal
Damien Roy, Ottawa
Peter Russell, McGill
Yvan Saint-Aubin, Montréal
David Sankoff, Ottawa
Dana Schlomiuk, Montréal
Robert Seiringer, McGill
Alexander Shnirelman, Concordia
Vasilisa Shramchenko, Sherbrooke
Alina Stancu, Concordia
Ron J. Stern, Concordia
Alain Tapp, Montréal
Francisco Thaine, Concordia
John A. Toth, McGill
Lennaert van Veen, UOIT
Roger Villemaire, UQAM
Luc Vinet, Montréal
Johannes Walcher, McGill
Timothy R. S. Walsh, UQAM
Pavel Winternitz, Montréal
Daniel T. Wise, McGill
Xiaowen Zhou, Concordia

Associate members

Nantel Bergeron, York
Robert Conte, CEA/Saclay
Stéphane Durand, Édouard-Montpetit
Bertrand Eynard, CEA/Saclay
Martin J. Gander, Genève
Pierre Ille, CNRS & Aix-Marseille

Marc Laforest, Polytechnique Montréal
Decio Levi, Roma Tre
Jun Li, Pharsight
Emmanuel Lorin de la Grandmaison, Carleton
Yiannis N. Petridis, Univ. Coll. London
Elisa Shahbazian, OODA Technologies
Marc Thiriet, CNRS, UPMC & INRIA Rocquencourt
Pierre Valin, Defence R&D Canada
Carolyne M. Van Vliet, Montréal & Miami
Jean-Paul Zolésio, INRIA Sophia Antipolis

Invited members

Mylène Bédard, Montréal
Louis G. Doray, Montréal
Laurent Habsieger, CNRS & Lyon 1
Pierre Lafaye de Micheaux, Montréal
Sheila Sandon, Nantes
Yuanli Zhang

Postdoctoral Fellows

Each year the CRM plays host to a large number of postdoctoral fellows. Their funding is provided through the NSERC and FRQNT postdoctoral programs, a NATO international program administered by NSERC, the CRM (usually in collaboration with the ISM), the CRM research laboratories, and individual research grants from CRM members. The list below includes postdoctoral fellows in residence at the CRM and those cofunded by the CRM. Some of the fellows were in residence at the CRM for only part of the year. The affiliation given is the institution where the doctorate was obtained.

Elif Fidan Acar, Toronto
Shabnam Akhtari, UBC
Ferenc Balogh, Concordia
Jessica Banks, Oxford
Sandro Bettin, Bristol
Alexander Bihlo, Wien
Cameron Brown, Florida
Renato Calleja, UT Austin
Vorrapan Chandee, Stanford
Adam Clay, UBC
Tiago Dinis da Fonseca, UPMC
Fabrizio Donzelli, Miami
Abdelkrim El Basraoui, Ottawa
Suresh Eswarathasan, Rochester
Renjie Feng, Northwestern
François Fillion-Gourdeau, McGill
Ke Gong, Henan
Philip Grech, ETH Zürich
Melita Hadzagic, McGill
Mariah E. Hamel, UBC
Adam J. Harper, Cambridge
Azadeh Jafari, EPFL
Gwenaël Joret, ULB
Nabil Kahouadji, Paris Diderot
Caroline Kalla, Bourgogne
Abdoulaye Sabou Kane, Laval
Ilya Karzhemanov, Edinburgh
Leila Kheibarshekan, Gent
Dmitry Kolomenskiy, Provence
Dimitris Koukoulopoulos, UI Urbana-Champaign
Eunghyun Lee, UC Davis
Antonio Lei, Cambridge
Alejandro Morales, MIT
Guyslain Naves, Joseph Fourier
Sarah Post, Minnesota
Stamatis Pouliasis, Aristotle
Danilo Riglioni, Roma Tre
Vivien Ripoll, Paris Diderot
Matthew Roberts, Bath
Mathew D. Rogers, UBC
Yakov Savelyev, Stony Brook
Jihye Seo, Harvard
Egor Shelukhin, Tel Aviv
David Sher, Stanford
Ethan C. Smith, Clemson
Marzena Szajewska, Bialystok

Agnieszka Tereszkiewicz, Bialystok
Carl Tipler, Nantes
Ihsan Ata Topaloglu, IU Bloomington
Pascal Turbis, Montréal
Matthias Westrich, Aarhus
Mark Wilde, Southern California
Driss Yacoubi, UPMC
Guofu Yu, Shanghai Jiao Tong
Yuxiang Zhang, Memorial

Visitors

Each year the CRM hosts a large number of visitors. The majority come to the Centre to participate in scientific activities organized or co-organized by the CRM. In 2012–2013 there were 10 activities in the thematic program and 557 researchers took part in these activities, 9 of which were held at the CRM itself. There were also 14 activities in the general program, 7 of which were held at the CRM; altogether 386 participants took part in these activities. Finally the multidisciplinary and industrial program featured 2 activities, one of which took place at the CRM; 58 researchers participated in the activity held at the CRM.

Long-term visitors

The following list only includes visitors who were in residence for at least four weeks.

Mattia Cafasso, Angers
Pierre Cagne, ÉNS
Chi-Yun Chuang, NTHU
Vladimir Dorodnitsyn, Keldysh Inst.
Gerard Freixas i Montplet, Paris Diderot
Alexandre Girouard, Neuchâtel
Elisa Gouvea Mauricio Ferreira, McGill
Jiří Hrivnák, TU Prague
Azadeh Jafari, Cardiff
Can Kozcaz, SISSA
Decio Levi, Roma Tre
Xiannan Li, UI Urbana-Champaign
Chunshan Lin, Tokyo
Frithjof Lutscher, Ottawa
Keivan Mallahi Karai, Jacobs
Luigi Martina, Salento
Alexi Morin-Duchesne, Montréal
Aïda Ouangraoua, Simon Fraser
Lucas Pastor, Savoie
Claude-Alain Pillet, Toulon
Raphaël Ponge, Seoul NU
Maksym Radziwill, Stanford
Libor Šnobl, TU Prague
Aleksander Strasburger, SGGW
Michael Sullivan, UMass Amherst
Marc Thiriet, UPMC
Zora Thomova, SUNY IT
Nicolae Vulpe, IMI Moldova
Oleksiy Zhedanov, Donetsk IPE
Wadim Zudilin, Newcastle, AU

Short-term visitors

The following visitors were in residence for less than four weeks.

Sergei Agafonov, João Pessoa
Silvia Anjos, IST
Joan Carles Artés, UA Barcelona
Alain Aspect, Inst. d'Optique
Ferenc Balogh, SISSA
Ram Band, Bristol
Jonathan Bober, Washington
Alina Bucur, UC San Diego
Goce Chadzitaskos, Doppler Inst.
Edmund Yik-Man Chiang, Hong Kong UST
Matthias Christandl, ETH Zürich
Robert Conte, CEA/Saclay
Charles Doran, Alberta
Anton Dzhamay, Northern Colorado
Paul D. Embrechts, ETH Zürich
Mauricio Adrian Escobar Ruiz, UNAM
Brooke Feigon, East Anglia

Rupert L. Frank, Princeton
Jürg Fröhlich, ETH Zürich
Leo Goldmakher, Toronto
María del Mar González Nogueras, UPC
Emir Gumrukcuoglu, Tokyo
Thomas Hoffmann-Ostenhof, Wien
Nail H. Ibragimov, Blekinge IT
Mourad E. H. Ismail, Central Florida
Alexander R. Its, IUPUI
Caroline Kalla, Orléans
Mikhail Karpukhin, Moscow SU
Takeshi Kobayashi, Toronto
Nam Le, Courant Inst.
Yi-Jen Lee, Chinese U Hong Kong
Frank Lemire, Windsor
Michael Levitin, Reading
Xiannan Li, UI Urbana-Champaign
Elijah Liflyand, Bar-Ilan
Jérôme Martin, IAP
Hiroshi Miki, Kyoto
Micah B. Milinovich, Mississippi
Willard Miller Jr., Minnesota
Robert V. Moody, Alberta
Emmy Murphy, MIT
Aleksander Yu. Orlov, Shirshov Inst.
Milena Pabiniak, Toronto
Leonid Parnovski, Univ. Coll. London
Subodh Patil, ÉNS
Alexei V. Penskoi, Moscow SU
Patrick Peter, IAP
Anne-Charlotte Philippe, INRIA Sophia Antipolis
Martin Pinsonnault, Western Ontario
Sarah Post, UH Mānoa
Vincent Rivasseau, Paris-Sud
Jeremy Rouse, Wake Forest
Jimena Royo-Letelier, Paris-Dauphine
Philippe Ruelle, UC Louvain
Detchat Samart, Texas A&M
Emmanuel Schertzer, UPMC
Wil H. A. Schilders, TU Eindhoven
Kai Schneider, TU Kaiserslautern
Chunhua Shan, York
Suzanne Shontz, Mississippi SU
Nadia Sidorova, Univ. Coll. London
Mark Siggers, Kyungpook NU
Philippe Sosoe, Princeton
Phan Thanh Nam, Cergy-Pontoise
Alexander Turbiner, UNAM
Daniel Ueltschi, Warwick
Vincent Vennin, IAP
Mark A. Walton, Lethbridge
Daqing Wan, UC Irvine
Simone Warzel, TU München
Hongmei Zhu, York
Peter Zograf, Steklov Inst.

List of Students Having Graduated in 2012–2013

The CRM members supervise a large number of graduate students. In this section we give information on the students supervised by CRM members who graduated in 2012–2013. The name of the student is followed by the name of his or her supervisor (or names of his or her supervisors), his or her institution, and his or her program. Some names may be missing from this list, because we have only included those that have been brought to our attention.

Ph.D. Students

Isabelle Ascah-Coallier
Abraham Broer
Université de Montréal
Mathematics (pure mathematics option)

Mohammad Bardestani
Andrew Granville
Université de Montréal
Mathematics (pure mathematics option)

Zied Ben Salah
Louis G. Doray; Manuel Morales
Université de Montréal
Mathematics (applied mathematics option)

Erwan Biland
Claude Levesque
Université Laval
Mathematics

Richard Bois
André Fortin; Michel Fortin
Université Laval
Mathematics

Yaiza Canzani
Dmitry Jakobson
McGill University
Mathematics

Francesc Castella
Henri Darmon
McGill University
Mathematics

Zhuge Chanjing
Michael C. Mackey
McGill University
Physiology

François Charest
François Lalonde; Octav Cornea
Université de Montréal
Mathematics (pure mathematics option)

François Charette
Octav Cornea
Université de Montréal
Mathematics (pure mathematics option)

Thierry Chekouo Tekougang
Alejandro Murua
Université de Montréal
Statistics

Mohammad Hossein Dehghan
Thierry Duchesne
Université Laval
Statistics

Olivier Delalleau
Yoshua Bengio
Université de Montréal
Computer science

Alpha Boubacar Diallo
Vladimir Makarenkov
Université du Québec à Montréal
Computer science

Plamen Dragiev
Vladimir Makarenkov
Université du Québec à Montréal
Computer science

Peyman Eslami
Pawel Gora; Abraham Boyarsky
Concordia University
Mathematics

Yasser Farhat
Frédéric Gourdeau; Thomas J. Ransford
Université Laval
Mathematics

Ionica Groparu-Cojocaru
Louis G. Doray; Manuel Morales
Université de Montréal
Mathematics (applied mathematics option)

Lenka Háková
Jiří Patera
Université de Montréal
Mathematics (applied mathematics option)

Salima Hassaine
Yann-Gaël Guéhéneuc; Sylvie Hamel
Université de Montréal
Computer science

Charles Hélou
Gilles Brassard
Université de Montréal
Computer science

Kassem Kalach
Gilles Brassard; Louis Salvail
Université de Montréal
Computer science

Johanna Karouby
Robert Brandenberger
McGill University
Physics

Hamid Khakdaman
Yves Bourgault; Marten Ternan
University of Ottawa
Chemical Engineering

Hussein Khreibani
Vasilisa Shramchenko
Université de Sherbrooke
Mathematics

Michelle Larouche
Jiří Patera
Université de Montréal
Mathematics (applied mathematics option)

Nima Lashkari
Alexander Maloney; Patrick Hayden
McGill University
Mathematics

Mehdi Layeghifard
Vladimir Makarenkov
Université du Québec à Montréal
Biology

Adrien Lemaitre
Gena Hahn; Benoît Larose
Université de Montréal
Computer science

Hui Li Liu
Xiaowen Zhou
Concordia University
Statistics

Amanollah Mehrabian
David A. Stephens
McGill University
Statistics

Alexi Morin-Duchesne
Yvan Saint-Aubin
Université de Montréal
Physics

Mohammad Najafi Ivaki
Alina Stancu
Concordia University
Mathematics

Guillaume Provencher
Yvan Saint-Aubin
Université de Montréal
Physics

Yassir Rabhi
Masoud Asgharian; Brenda MacGibbon
McGill University
Statistics

Hela Romdhani
Lajmi Lakhal-Chaieb; Louis-Paul Rivest
Université Laval
Statistics

Olivier Rouch
Madrane Aziz; Paul Arminjon
Université de Montréal
Mathematics (applied mathematics option)

Mireille Schnitzer
Erica E. M. Moodie
McGill University
Biostatistics

Narinder Sharma
Dominic Rochon; Kuldeep S. Charak
Université du Québec à Trois-Rivières
Mathematics

Karine St-Onge
François Major; Sylvie Hamel
Université de Montréal
Computer science

Bocar Amadou Wane
José Manuel Urquiza; André Fortin
Université Laval
Mathematics

Alisha Wissanji
Alexander Maloney; Keshav Dasgupta
Université de Montréal
Physics

Yongling Xiao
Erica E. M. Moodie; Michal Abrahamowicz
McGill University
Biostatistics

Wei Xue
Robert Brandenberger
McGill University
Physics

M.Sc. Students

Albert Ajonkeu
Louis-Paul Rivest
Université Laval
Statistics

Farid Aouji
Lajmi Lakhal-Chaieb; Belkacem Abdous
Université Laval
Mathematics

Samuel April
Louis-Paul Arguin
Université de Montréal
Mathematics (applied mathematics option)

Farzad Aryan
Andrew Granville
Université de Montréal
Mathematics (pure mathematics option)

Adétona O. Paterne Bada
Louis-Paul Rivest
Université Laval
Statistics

Nadia Bahri
Qazi Ibadur Rahman
Université de Montréal
Mathematics (pure mathematics option)

Jean-François Bégin
Mylène Bédard; Patrice Gaillardetz
Université de Montréal
Mathematics (applied mathematics option)

Latifa Ben Hadj Slimene
Éric Marchand
Université de Sherbrooke
Mathematics

Fabiola Bene Tchaleu
David Haziza; Pierre Duchesne
Université de Montréal
Statistics

Ryan Benty
Alina Stancu
Concordia University
Mathematics

Francesca Bergamaschi
Adrian Iovita
Concordia University
Mathematics

Thanina Berkane
Christian Léger; Piere Duchesne
Université de Montréal
Statistics

Valentin Bisson
Yoshua Bengio
Université de Montréal
Computer science

Timothy Blais
Alexander Maloney
McGill University
Mathematics

Éloïse Boiteau
André Fortin
Université Laval
Mathematics

Samuel Boucher
Vestislav Apostolov
Université du Québec à Montréal
Mathematics

Catalina Butnariu
David Haziza
Université de Montréal
Statistics

Hassan Choueib
Michel C. Delfour
Université de Montréal
Mathematics (applied mathematics option)

Paul Robert Chouha
Alain Tapp; Gilles Brassard
Université de Montréal
Computer science

Maurice-Étienne Cloutier
Jean-Marie De Koninck; Claude Levesque
Université Laval
Mathematics

Marc-Alexandre Côté
Shengrui Wang; Maxime Descoteaux
Université de Sherbrooke
Mathematics

Bianca Côté-Brunet
Jean-François Angers; Manuel Morales
Université de Montréal
Statistics

Miguel Alfredo Cutimanco Panduro
Virginie Charette; Vasilisa Shramchenko
Université de Sherbrooke
Mathematics

Pierre-Luc Cyr
Jean-François Angers
Université de Montréal
Statistics

Philippe Delorme
Pierre Lafaye de Micheaux
Université de Montréal
Statistics

Marie-Hélène Descary
Fabrice Larribe
Université du Québec à Montréal
Mathematics (statistics option)

Caroline Deschênes
Christian Léger
Université de Montréal
Statistics

Jean-François Désilets
Pavel Winternitz
Université de Montréal
Physics

Hugo Drouin-Vaillancourt
Alain Tapp
Université de Montréal
Computer science

Yeting Du
Abbas Khalili; Johanna Nešlehová
McGill University
Statistics

Mathieu Dupont
Fabrice Larribe
Université du Québec à Montréal
Mathematics (statistics option)

David Émond
Nadia Ghazzali
Université Laval
Mathematics

Laura C. Eslava Fernández
Louigi Addario-Berry
McGill University
Mathematics

Andrew Fenwick
Galia Dafni
Concordia University
Mathematics

Heinz Fiedler
Alain Tapp
Université de Montréal
Computer science

Iulian Fransinescu
René Ferland
Université du Québec à Montréal
Mathematics

Alexandre Fréchette
Bruce Shepherd
McGill University
Mathematics

Yves Gagnon
Nadia El-Mabrouk
Université de Montréal
Bioinformatics

Ludovick Gagnon
José Manuel Urquiza
Université Laval
Mathematics

Shan Gao
Adrian Iovita
Concordia University
Mathematics

Gabriel Girard
Maxime Descoteaux
Université de Sherbrooke
Mathematics

Mireille Guerrier
Louis-Paul Rivest
Université Laval
Statistics

Dezhao Han
José Garrido
Concordia University
Actuarial science

Julie Héroux
Erica E. M. Moodie
McGill University
Biostatistics

Eliot Hijano
Alexander Maloney
McGill University
Mathematics

Zahraa Issa
Matilde Lalín
Université de Montréal
Mathematics (pure mathematics option)

Samuel Johnson
Marni Mishna
Simon Fraser University
Mathematics

Philip Lagogianis
Alexander Maloney
McGill University
Mathematics

Sandra Larrivée
Jean-François Renaud
Université du Québec à Montréal
Mathematics

Jean-Sébastien Lechasseur
Matilde Lalin
Université de Montréal
Mathematics (pure mathematics option)

Jean-Sébastien Lévesque
Robert Guénette
Université Laval
Mathematics

Erin Lundy
David B. Wolfson; David A. Stephens
McGill University
Statistics

Dominique Maheux
Robert Guénette
Université Laval
Mathematics

Céline Maistret
Hershy Kisilevsky; Adrian Iovita
Concordia University
Mathematics

Viktor Marushka
Iosif Polterovich
Université de Montréal
Mathematics (pure mathematics option)

Jérémie Mathieu
Dominic Rochon; Louis Marchildon
Université du Québec à Trois-Rivières
Physics

Annaliza McGillivray
Abbas Khalili
McGill University
Statistics

Nassim Mojaverian
Erica E. M. Moodie
McGill University
Biostatistics

Marcela Molinie
Jacques Bélair
Université de Montréal
Mathematics (applied mathematics option)

Vanessa W. K. Ng
Frédéric Lesage
École Polytechnique de Montréal
Electrical Engineering

Jean-François Nolet
Virginie Charette
Université de Sherbrooke
Mathematics

Ivo Pendev
Pawel Gora
Concordia University
Mathematics

David Olivier Pham
Manuel Morales
Université de Montréal
Statistics

Marta Pieropan
Adrian Iovita
Concordia University
Mathematics

Dany Pilon
Mathieu Boudreault
Université du Québec à Montréal
Mathematics (financial mathematics option)

Alan Regis
Wei Sun
Concordia University
Statistics

Reza Sadoughianzadeh
Adrian Iovita
Concordia University
Mathematics

Becem Saidani
Éric Marchand; Maxime Descoteaux
Université de Sherbrooke
Mathematics

Etienne Saint-Amant
Maxime Descoteaux
Université de Sherbrooke
Mathematics

Modou Sene
Thierry Duchesne
Université Laval
Statistics

David Simonyan
Thierry Duchesne
Université Laval
Statistics

Kevin Sookhee
Wei Sun
Concordia University
Statistics

Dong Sun
Yogendra P. Chaubey
Concordia University
Statistics

Yasmine Tawfik
Robert G. Owens
Université de Montréal
Mathematics (applied mathematics option)

Hervé Tchouake Tchuiguep
François Perron
Université de Montréal
Statistics

Tommy Thomassin
Geneviève Gauthier; Mathieu Boudreault
HEC Montréal
Financial Engineering

Marie-Hélène Toupin
Louis-Paul Rivest
Université Laval
Statistics

Hugo Tremblay
Gilbert Labelle
Université du Québec à Montréal
Mathematics

Véronique Tremblay
Anne-Catherine Favre; Thierry Duchesne
Université Laval
Statistics

Benoit Tricot
Maxime Descoteaux
Université de Sherbrooke
Mathematics

Loukia Tsakanikas
Lennaert van Veen; Eusebius Doedel
Concordia University
Mathematics

Jean-Philippe Turcotte
Éric Marchand
Université de Sherbrooke
Mathematics

Fan Zhang
Yogendra P. Chaubey
Concordia University
Statistics

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, an Executive Committee, and a Committee of Directors of Laboratories. In 2012–2013 the members of the Local Scientific Committee were Christian Genest (McGill University), Andrew Granville (Université de Montréal), Dmitry Jakobson (McGill University), François Lalonde (Université de Montréal; Director of the CRM), and Lea Popovic (Concordia University). The Executive Committee consists of the CRM Director and the Deputy Directors. For more information, the reader may consult the web site crm.math.ca/apropos/CRM_structure_an.shtml.

Board of Directors

The Board of Directors is composed of:

- The Director (ex officio);
- A member of the Executive Committee nominated by the Board for a two-year mandate;
- Two regular 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 Vice-Principal, Research, of each of the main partner universities of the CRM, or his representative;
- 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.

Here are the members of the Board of Directors for 2012–2013.

Sophie D'Amours, Vice-Rector (Research)
Université Laval

Graham Carr, Vice-President (Research)
Concordia University

Christian Genest
McGill University

Jacques Hurtubise
Vice-Principal (Research) Representative
McGill University

John Harnad
Concordia University

François Lalonde, Director of the CRM
Université de Montréal

Odile Marcotte, Deputy Director of the CRM
Université du Québec à Montréal

Yves Mauffette, Vice-Rector (Research)
Université du Québec à Montréal

Christiane Rousseau
Université de Montréal

Geneviève Tanguay, Vice-Rector (Research)
Université de Montréal

Chantal David (Concordia University) and **Octav Cornea** (Université de Montréal), Deputy Directors of the CRM, were invited members.

Committee of Directors of Laboratories

The Committee of Directors of Laboratories is composed of the Director, the Directors of the nine CRM Laboratories and the Deputy Directors of the Centre. It meets at least once a year to discuss any question that concerns the laboratories. The Directors of the laboratories are:

François Bergeron (UQAM)
LaCIM — Combinatorics and Theoretical Computer Science

Steven P. Boyer (UQAM)
CIRGET — Geometry and Topology

Henri Darmon (McGill University)
CICMA — Number Theory and Algebra

André Fortin (Université Laval)
GIREF — Modelling and Numerical Simulation

Christian Genest (McGill University)
Statistics

John Harnad (Concordia University)
Mathematical Physics

Dmitry Jakobson (McGill University)
Mathematical Analysis

Jean-Marc Lina (École de technologie supérieure)
PhysNum — Medical Imaging and Pharmacometrics

Adam M. Oberman (McGill University)
Applied Mathematics (from January 8th, 2013)

Robert G. Owens (Université de Montréal)
Applied Mathematics (until January 7th, 2013)

International Scientific Advisory Committee

The International Scientific Advisory Committee consists of distinguished researchers from Canada and abroad. Its members are either mathematicians or scientists with close ties to the mathematical sciences. The Advisory Committee is kept informed regularly of the activities of the Centre through the Director. The Committee makes recommendations about the general scientific orientations of the CRM and gives advice about proposed scientific activities.

Martin Barlow received his undergraduate degree from the University of Cambridge in 1975 and completed his doctoral degree with David Williams at the University College of Swansea in Wales (1978). Since then he has been a leading researcher in probability theory, in particular diffusion in fractals and other disordered media. He held a Royal Society University Research Fellowship at the University of Cambridge from 1985 to 1992, when he joined the Mathematics Department at the University of British Columbia. He is currently Professor of Mathematics at UBC. He has held a number of visiting professorships at leading universities. Martin Barlow gave an invited lecture at the 1990 ICM in Kyoto and was an invited lecturer at the prestigious Saint-Flour Summer School in 1995. In 2008 he received the Jeffery-Williams Prize of the Canadian Mathematical Society and in 2009 the CRM –Fields– PIMS Prize. Other distinctions include the Rollo Davidson Prize from the University of Cambridge and the Junior Whitehead Prize from the London Mathematical Society. He has been a leader of the international probability community as a lead organizer of numerous conferences, Associate Editor of all the top probability journals, and Editor-in-Chief of the Electronic Communications in Probability. He has been a Fellow of the Institute of Mathematical Statistics since 1995 and of the Royal Society of Canada since 1998. In 2006 he was elected Fellow of the Royal Society (London).

A specialist of probability theory and its applications, **Gérard Ben Arous** arrived to the Courant Institute (NYU) as a Professor of Mathematics in 2002. He was appointed Director of the Courant Institute and Vice Provost for Science and Engineering Development in September 2011. A native of France, Professor Ben Arous studied Mathematics at the École normale supérieure and earned his Ph.D. from the Université Paris Diderot (1981). He has been a Professor at the Université Paris-Sud, at the École normale supérieure, and more recently at the École Polytechnique Fédérale de Lausanne, where he held the Chair of Stochastic Modelling. He was Chair of the Department of Mathematics at the Université Paris-Sud and the Departments of Mathematics and Computer Science at the École normale supérieure. He also founded a Mathematics Research Institute in Lausanne, the Bernoulli Center. He is the managing editor (with Amir Dembo, Stanford) of one of the main journals in his field, *Probability Theory and Related Fields*.

Professor Ben Arous works on probability theory (stochastic analysis, large deviations, random media and random matrices) and its connections with other domains of mathematics (partial differential equations, dynamical systems), physics (statistical mechanics of disordered media), and industrial applications. He is mainly interested in the time evolution of complex systems and the universal aspects of their long-time behaviour and of their slow relaxation to equilibrium, in particular how complexity and disorder imply aging. He is a Fellow of the Institute of Mathematical

Statistics (as of August 2011) and an elected member of the International Statistical Institute. He was a plenary speaker at the European Congress of Mathematics, an invited speaker at the International Congress of Mathematicians, received a senior Lady Davis Fellowship (Israel), the Rollo Davidson Prize (Imperial College, London), and the Montyon Prize (French Academy of Sciences).

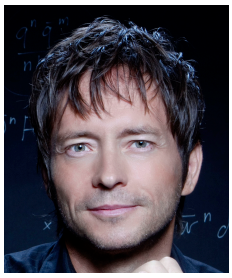
Allan Borodin received his B.A. in Mathematics in 1963 (from Rutgers University), his M.Sc. in Electrical Engineering and Computer Science in 1966 (from Stevens Institute of Technology), and his Ph.D. in Computer Science in 1969 (from Cornell University). He was a systems programmer at Bell Laboratories in New Jersey from 1963 to 1966 and a Research Fellow at Cornell from 1966 to 1969. Since 1969, he has been a professor in the Department of Computer Science at the University of Toronto, where he became a full professor in 1977. He was department chair from 1980 to 1985. Professor Borodin is a world leader in the mathematical foundations of computer science and has made fundamental contributions to many areas, including algebraic computations, resource tradeoffs, routing in interconnection networks, parallel algorithms, on-line algorithms, and adversarial queuing theory. Professor Borodin has been the editor of many journals, including the SIAM Journal on Computing. He has held positions on, or been active in, dozens of committees and organizations, both inside and outside the University, and has held several visiting professorships internationally. In 1991 Professor Borodin was elected a Fellow of the Royal Society of Canada and in 2008 he received the CRM –Fields–PIMS Prize.

Stephen E. Fienberg is Maurice Falk University Professor of Statistics and Social Science at Carnegie Mellon University. He is the Carnegie Mellon codirector of the Living Analytics Research Centre. Fienberg received his hon. B.Sc. in Mathematics and Statistics from the University of Toronto (1964) and his A.M. and Ph.D. degrees in Statistics from Harvard University (1965, 1968).

Professor Fienberg has served as Dean of the College of Humanities and Social Sciences at Carnegie Mellon and as Vice President for Academic Affairs at York University, in Toronto, as well as on the faculties of the University of Chicago and the University of Minnesota. He has been a founding editor of a number of statistical journals. He has been Vice President of the American Statistical Association and President of the Institute of Mathematical Statistics and the International Society for Bayesian Analysis.

Fienberg's research includes the development of statistical methods, especially tools for categorical data analysis and the analysis of network data, algebraic statistics, causal inference, statistics and the law, machine learning, and the history of statistics.

Fienberg is a member of the U.S. National Academy of Sciences, and a fellow of the Royal Society of Canada, the American Academy of Arts and Sciences, and the American Academy of Political and Social Science, as well as a fellow of the American Association for the Advancement of Science, the American Statistical Association, the Institute of Mathematical Statistics, and an elected member of the International Statistical Institute.



Edward Frenkel grew up in Russia and then moved to the US. He received his Ph.D. in Mathematics from Harvard University at the age of 23 after one year of study. He stayed on at Harvard, first as a Junior Fellow at the prestigious Harvard Society of Fellows, and then as an Associate Professor. He was offered a Full Professorship at the University of California, Berkeley at the age of 28 (one of the youngest ever), and he has been Professor of Mathematics at Berkeley since then. In 2008 he received the first Chaire d'Excellence award from the Fondation Sciences Mathématiques de Paris.

Frenkel has authored two books and about 80 articles in mathematical journals, and he has lectured on his work around the world. Among his other awards are the Hermann Weyl Prize and the Packard Fellowship in Science and Engineering.

Susan Friedlander is currently Director of the Center for Applied Mathematical Sciences and Professor of Mathematics at the University of Southern California. She obtained her Doctoral degree at Princeton University in 1972. She

has published extensively in the areas of differential equations and fluid mechanics. She has been very active on numerous committees and evaluation panels, including the Council of the American Mathematical Society and the Board on Mathematical Sciences and Their Applications of the National Academies. She has also been involved continuously in the organization of conferences and workshops; in particular she was a member of the AMS-Shanghai Joint Meeting Program Committee. She has served on numerous AMS editorial boards and university committees. She has been honoured with several academic awards, including the Institut Henri-Poincaré Medal, the Gauthier-Villars Prize for Nonlinear Analysis, and the University of Illinois Scholar Award (in 2003). Over the years, she has been a frequent invited lecturer in the United States and around the world.

Mark Goresky has been a member of the Institute for Advanced Study in Princeton since 1994. He received his B.Sc. from the University of British Columbia in 1971 and a Ph.D. from Brown University in 1976. In 1986 he was elected to the Royal Society of Canada. He was awarded the Jeffery-Williams Prize of the Canadian Mathematical Society in 1996 and the Steele Prize of the American Mathematical Society in 2002 (jointly with R. MacPherson). He was a member of the editorial board of the Canadian Journal of Mathematics from 1997 to 2000 and is currently a member of the editorial board of the Bulletin of the American Mathematical Society. He is a world expert in geometric representation theory.

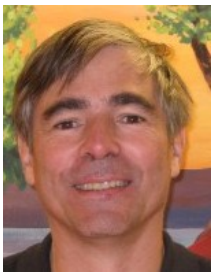
Mark L. Green has been a professor in the UCLA Department of Mathematics since 1982. He received his Ph.D. from Princeton University in 1972 and was Director of the Institute for Pure and Applied Mathematics from 2001 to 2008. Mark Green has received numerous honours during his career. In particular, he was an invited speaker at the International Congress of Mathematicians in Berlin in 1998. He was a plenary speaker at the Abel Centennial held in Oslo in 2002 and the Hodge Centennial held in Edinburgh in 2003. Professor Green's services to the mathematical community are extensive. He was a member of the Board of Trustees at the Claremont Center for the Mathematical Sciences and a member of the Board of Directors of the Center for Mathematics and Teaching. Professor Green also served on the NSERC Major Resources Support Committee and was the editor of the Journal of Algebraic Geometry. His research interests are in commutative algebra, algebraic geometry, and applied mathematics.

Laurent Habsieger has been a senior researcher at the Centre national de la recherche scientifique (CNRS) since 2002. A former student at the École Normale Supérieure (ENS), he completed his Ph.D. in Strasbourg before spending one year at the IMA (Minneapolis) as a postdoctoral fellow. He was then a professor at the Université du Québec à Montréal (UQAM) for two years. In 1990 he joined the CNRS as a junior researcher in Bordeaux and in 2002 he accepted a position as senior researcher in Lyon. Laurent Habsieger then managed the national research group in number theory for 8 years. He was deputy director of his laboratory for 5 years and supervised three Franco-Hungarian research programs. In 2011 the CNRS launched the UMI CRM and he was appointed co-director of the UMI with François Lalonde, director of the CRM.

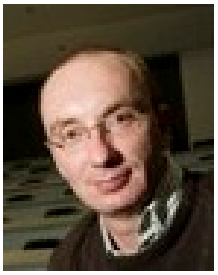
Having completed his thesis in combinatorics, Laurent Habsieger broadened its expertise to number theory. He is the author of around 40 scientific articles in many areas of mathematics: combinatorics, arithmetic, special functions, coding theory, analysis, etc.

Barbara Lee Keyfitz has been a professor at the Ohio State University since January 2009. She served as Director of the Fields Institute for Research in Mathematical Sciences from 2004 to 2008. From 2000 to 2008, she was John and Rebecca Moores Professor of Mathematics at the University of Houston, which she joined in 1987, following appointments at Columbia, Princeton, and Arizona State University. She studied at the University of Toronto and obtained her Ph.D. at the Courant Institute (NYU). Barbara Keyfitz is a Fellow of the American Association for the Advancement of Science and the recipient of the 2005 Krieger–Nelson Prize of the Canadian Mathematical Society. She serves as Treasurer of the International Council of Industrial and Applied Mathematics and has been a member of several

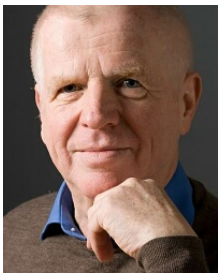
editorial boards. Her research interests are in the field of nonlinear partial differential equations.



A mathematician and physicist by training, **François Lalonde** holds a Doctorat d'État (1985) from the Université Paris-Sud in the field of differential topology. His fields of interest include symplectic topology, Hamiltonian dynamics, and the study of infinite-dimensional groups of transformations. He has been a member of the Royal Society of Canada since 1997 and was a Killam Research Fellowship recipient in 2000–2002. He holds the Canada Research Chair in the field of Symplectic Geometry and Topology at the Department of Mathematics and Statistics of the Université de Montréal. François Lalonde was a plenary speaker at the First Canada–China congress in 1997; part of his work in collaboration with Dusa McDuff was presented in her plenary address at the ICM 1998 in Berlin. He was also an invited speaker at the ICM 2006 in Madrid.



Claude Le Bris obtained his doctorate from the École Polytechnique in France and his accreditation to supervise research from the Université Paris Dauphine in 1997. His research interests include mathematical analysis and numerical methods for partial differential equations and their applications to molecular simulation, multiscale problems, materials science, and continuum mechanics. He is a world-renowned expert in the mathematics of quantum chemistry and the computation of the electronic structure in quantum physics. Claude Le Bris received the Blaise Pascal Prize from the Académie des Sciences in 1999, the "CS 2002 Prize in Scientific Computing," and the Giovanni Sacchi-Landriani Prize from the Istituto Lombardo in 2002. He was Civil Engineer-in-Chief and Research Scientist at the École Nationale des Ponts et Chaussées and scientific leader of the MICMAC project at INRIA. Claude Le Bris has been a member of several program committees of international conferences and thematic years organized by research centres. He was co-editor of *Mathematical Modelling and Numerical Analysis* and editor of the *Applied Mathematics Research eXpress*. He has supervised 12 Ph.D. students and authored five books, 80 articles published in international journals, and 20 articles included into books or conference proceedings. He has given 90 invited lectures at international conferences and a series of Aisenstadt lectures at the CRM (in the fall of 2009).



Claus Michael Ringel received the Diplom (1968) and Ph.D. in Mathematics from the Goethe-Universität Frankfurt am Main in 1969 and the Habilitation from the Eberhard Karls Universität Tübingen in 1972. He taught briefly at Carleton University in Ottawa (1970–1972). From 1978 to 2010 he was Professor of Mathematics at the Universität Bielefeld in Germany, where he is now Professor Emeritus. He is in addition Visiting Chair Professor at Shanghai Jiao Tong University in China. Claus Ringel's research is in Representation Theory, the study of concrete realizations of abstract algebraic structures. His work has been profoundly influential in the development of the theory of representations of finite-dimensional algebras, in particular quivers, hereditary algebras, Ringel–Hall algebras, and quantum groups. He has had, and continues to have, a leading role in a number of SFB (Sonderforschungsbereich: Collaborative Research Centre) in Germany in the area of representation theory.

Since 2003 **Keith F. Taylor** has been teaching at Dalhousie University where he notably held the position of dean at the Faculty of Science from 2003 to 2008. He is currently Associate Vice-President Academic for the Outreach and International Programs. After obtaining his Ph.D. (1976) at the University of Alberta, he became Assistant Professor and Associate Professor at the University of Saskatchewan. In 1996–1997, Professor Taylor won the Student Union Teaching Excellence Award, followed by the Master Teacher Award in 2001. He finds his primary research interests in Abstract Harmonic Analysis and Wavelet Analysis, Spectral Problems Arising in Chemistry and Technology Enhanced Pedagogy. He has supervised five Ph.D. theses and nine M.Sc. theses and is still the founding director of the Math Readiness Summer Camps created in 1996.

Akshay Venkatesh has been a professor at Stanford University since September 2008. He obtained his Ph.D. from Princeton University in 2002, was C.L.E. Moore Instructor at MIT from 2002 to 2004, and a professor at the Courant Institute (NYU) from 2004 to 2008. Akshay Venkatesh has received many prizes and fellowships since the beginning of his career, in particular the Sloan Foundation Fellowship (2007), the Salem Prize (2007), the David and Lucile Packard Foundation Fellowship (2007–2012), and the SASTRA Ramanujan Prize (2008). In 2010 he was Aisenstadt Chair lecturer at the CRM, within the framework of the thematic semester on Number Theory as Experimental and Applied Science. His research interests are in number theory and automorphic forms, including representation theory, dynamics on homogeneous spaces, and arithmetic algebraic geometry.

Geneviève Tanguay, Vice-Rector (Research), Université de Montréal, is an ex-officio member of the International Scientific Advisory Committee. **Chantal David** (Concordia University), **Octav Cornea** (Université de Montréal), and **Odile Marcotte** (Université du Québec à Montréal), all Deputy Directors of the CRM, are invited members of the Committee.

CRM Administrative and Support Staff

The Director's Office

François Lalonde
Director

Octav Cornea
Deputy Director, CRM Prizes

Chantal David
Deputy Director, *Le Bulletin du CRM* and joint publications with the AMS and Springer

Odile Marcotte
Deputy Director, Annual Report and Coordination with Related Fields

Administration

Vincent Masciotra
Head of Administration

Julie Labbé
Secretary

Guillermo Martinez-Zalce
Research Laboratories Administrative Coordinator

Diane Brulé-De Filippis
Administrative Assistant

Scientific Activities

Louis Pelletier
Coordinator

Louise Letendre
Administrative Assistant

Sakina Benhima
Project Manager

Computer Services

Daniel Ouimet
Systems Administrator

André Montpetit
Office Systems Manager (half-time)

Publications

André Montpetit
TEX Expert (half-time)

Communications

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Mandate of the CRM

The Centre de recherches mathématiques (CRM) is one of the first and foremost institutes of mathematical research in the world. Indeed it was the first international institute to introduce the famous thematic programs (in 1984, at the same time as the MSRI). These programs were created independently by the two institutes and were an inspiration for the tens of institutes that were created in Europe and Asia after 1984. This model turned out to be the most creative and efficient means of fostering research and its applications to state-of-the-art technology. Although the initial programs were concentrated in pure and applied mathematics, they are now much broader and include all the fields that use sophisticated mathematical methods: theoretical physics, classical and quantum information, medical imaging, statistics, probabilistic methods on large-scale networks, etc.

The CRM was created in 1969 by the Université de Montréal through a special grant from the National Research Council Canada. It became an NSERC national research centre in 1984. It is currently funded by NSERC (Natural Sciences and Engineering Research Council of Canada), by the Government of Québec through the FRQNT (Fonds de recherche du Québec – Nature et technologies), by the Université de Montréal, as well as McGill University, the Université du Québec à Montréal, Concordia University, the University of Ottawa, the Université Laval, the Université de Sherbrooke, and by private donations. The mission of the CRM is to support research in mathematics and closely related disciplines and to provide leadership in the development of the mathematical sciences in Canada.

The CRM carries on its mission and national mandate in several ways:

- it organizes each year a series of scientific events on a specific theme (high-profile lectures, workshops, summer schools, etc.),
- its general program and its multidisciplinary and industrial program provide funding for conferences and special events at the CRM and across the country,
- each year it invites, through the Aisenstadt Chair, one or more distinguished mathematicians to give advanced courses as part of its thematic program,
- it awards four prizes yearly: the CRM–Fields–PIMS Prize recognizing major contributions to mathematics, the André-Aisenstadt Prize given for outstanding work carried out by a young Canadian mathematician, the CAP–CRM Prize for exceptional achievement in theoretical and mathematical physics, and the CRM–SSC Prize for exceptional contributions to statistics in early career,
- it publishes technical reports and books (some of its collections are published jointly with the AMS or Springer),
- it has an extensive postdoctoral fellowship program, with more than thirty postdoctoral fellows on site, funded in partnership with other organizations and researchers,
- it informs the community of its activities through its newsletter, *Le Bulletin du CRM*, and its web site at http://crm.math.ca/,
- it participates, with the other two Canadian institutes, in groundbreaking national initiatives, for instance the Mprime network (formerly Mathematics of Information Technology and Complex Systems). The institutes sponsor the Annual Meetings of the Mathematical Sciences Societies (CMS, SSC, CAIMS), the development of the mathematical sciences in the Atlantic provinces through AARMS, and other activities organized outside the three institutes. They also participate in the National Institute for Complex Data Structures jointly with the Canadian statistical community.

This national mandate is complemented by, and indeed supported by, a long-standing vocation of promoting research in the mathematical sciences in Québec. For instance,

- the CRM supports research through its ten research laboratories spanning most of the important areas of the mathematical sciences,
- it supports, through partnership agreements, a group of local researchers chosen mainly from departments of mathematics and statistics, but also computer science, physics, economics, engineering, etc.,
- it organizes series of regular seminars and lecture courses on different areas of the mathematical sciences,
- it sponsors joint activities with the Institut des sciences mathématiques (ISM), including the CRM–ISM colloquia, graduate courses offered by distinguished visitors, and a program of postdoctoral fellowships,
- it works actively at developing contacts with industry, especially through the Montreal Industrial Problem Solving Workshops.

The CRM fulfils its national mission by involving the largest possible number of Canadian mathematicians

in its scientific programs, both as participants and as organizers. It also supports many events taking place outside Montréal and the Province of Québec. The CRM is reaching out to the general public through two ongoing programs: the *Accromath* magazine, which was created jointly by the CRM and the ISM and has won many international prizes and the Prix spécial de la Ministre de l'Éducation (in 2008), and the Grandes Conférences du CRM, which allow a broad public to attend lectures given by outstanding international scientists.

The director of the CRM is assisted by two managerial structures: the Board of Directors and the International Scientific Advisory Committee. The Advisory Committee is a group of internationally renowned mathematicians from Canada and abroad, who approve scientific programs and thematic years, choose recipients of the André-Aisenstadt Prize, and suggest new scientific avenues to explore.