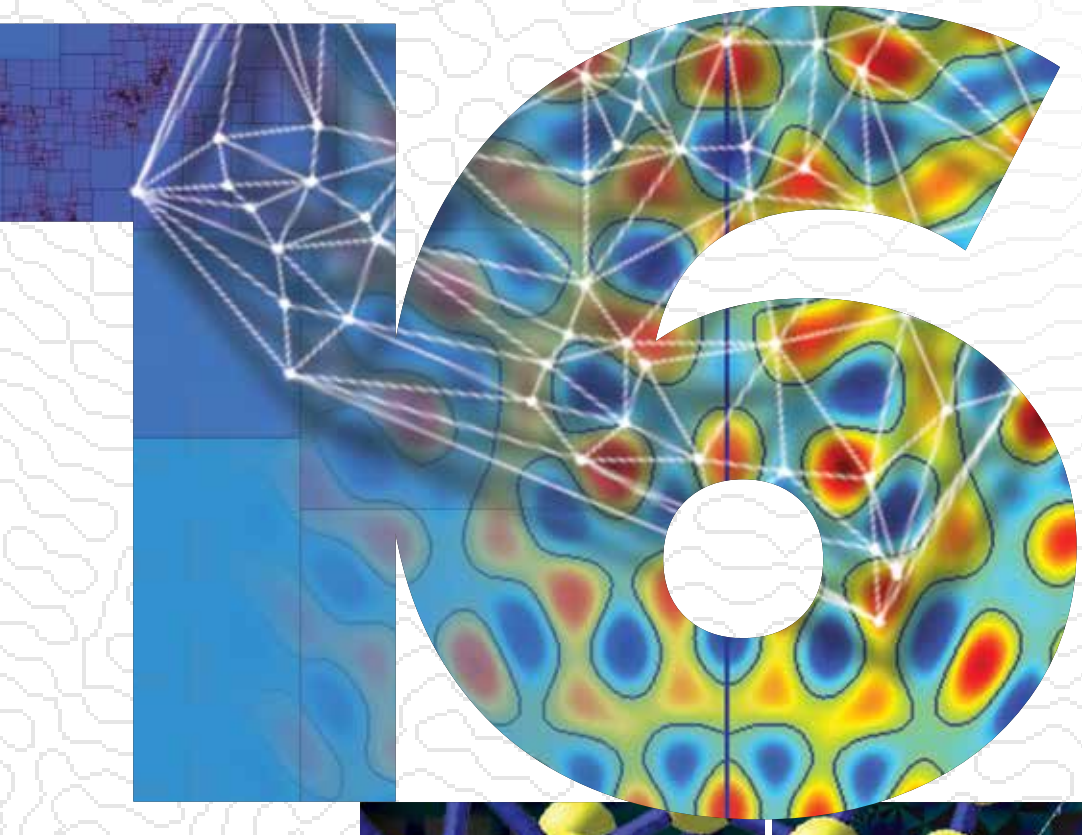
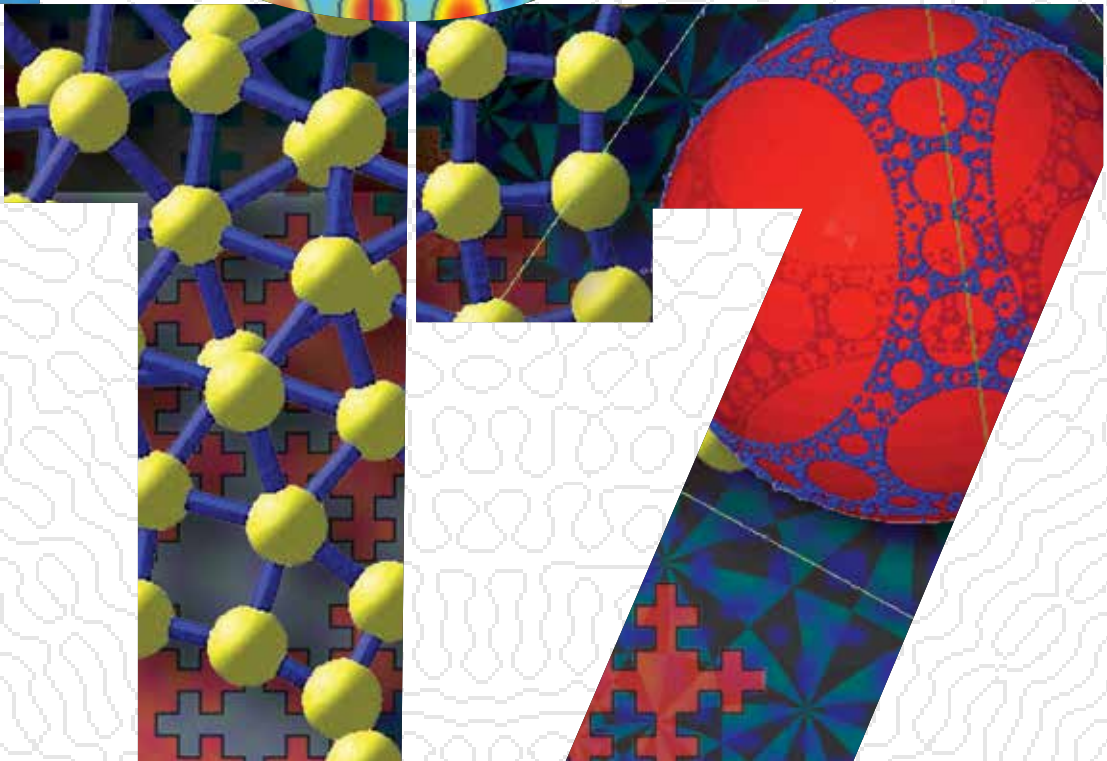
CENTRE
DE RECHERCHES
MATHÉMATIQUES



2016-2017 ANNUAL REPORT



SUMMARY

SUMMARY

Presentation

In 2016–2017 the CRM thematic program covered a large spectrum of areas of mathematics. Indeed the first semester (from August 22 to November 18, 2016) dealt with probabilistic methods in geometry, topology, and spectral theory. It was organized by a committee of sixteen researchers, including seven professors at McGill University: I thank all of them for having spearheaded a wonderful program, consisting of five workshops (in particular a workshop honouring Barry Simon) and three series of lectures by Aisenstadt Chairholders (Nalini Anantharaman, Yuval Peres, and Scott Sheffield). The other thematic semester was dedicated to algebra and words in combinatorics and was organized by Srečko Brlek and Franco Saliola, both professors at UQAM; I am also grateful to them for their splendid work. For that semester the Aisenstadt Chairholders were Boris Adamczewski (CNRS and Université de Lyon) and Vic Reiner (University of Minnesota). One characteristic of the semester on algebra and words in combinatorics was the pairing of four workshops and four schools: each workshop was preceded by a school whose participants were introduced to the topic of the workshop.

The 2016–2017 academic year also featured four summer schools (including the second Deep Learning Summer School) and a short thematic program on statistical causal inference and its applications to genetics (organized by Erica E. M. Moodie and David A. Stephens, among others). The 2016–2017 academic year also featured four awards: the André Aisenstadt Prize was awarded to Jacob Tsimerman, the CRM–SSC Prize to Lei Sun, the CRM–Fields–PIMS Prize to Henri Darmon, and the ACP–CRM Prize to Raymond Laflamme. Two lectures in the "Grandes Conférences du CRM" series were delivered, respectively on the mathematics of artificial intelligence (by Alain Tapp) and on Paul Lévy and black swans (by Gérard Ben Arous, Chairman of the CRM International Scientific Advisory Committee).

The CRM Management Committee spent a lot of time and effort preparing the 50th anniversary of the CRM, which will be celebrated in 2018–2019. I am especially grateful to Louigi Addario-Berry (CRM Deputy Director, Scientific Programs). He designed a great program with the help of many CRM members and I am confident that this program will have a broad impact on the international mathematical community. Louigi Addario-Berry was also responsible for a large grant application to the Simons Foundation. On March 27, 2017, within the framework of the "Targeted Grants to Institutes" program, the Simons Foundation awarded a grant of US$ 976,320 to the CRM for a five-year period. This grant will enable us to create the Simons CRM Scholar-in-Residence Program, which will attract to the CRM many top-notch international researchers. I would also like to thank Galia Dafni, CRM Deputy Director and professor at Concordia University, for her remarkable work on the CRM publications and the "Bulletin du CRM" over a period of four years. We will miss her very much!

I would like to point out that we have enlarged the CRM Board of Directors and that it now includes two prominent representatives of the private sector: Mrs. Hélène Desmarais (Founder, Chairman of the Board, and Chief Executive Officer of the "Centre d'entreprises et d'innovation de Montréal") and Dr. Luis Seco (Cofounder and CEO of Sigma Analysis & Management). We are very proud of their implication and thank them warmly for their help. Finally I wish to thank all of our partners, who made all the aforementioned activities possible: the FRQNT (Québec), NSERC (Canada), the Conseil national de la recherche scientifique (France), and the National Science Foundation (United States).

Luc Vinet
Director of the CRM
January 2018

CRSNG NSERC

Fonds de recherche sur la nature et les technologies Québec

NSF

cnrs

THEMATIC PROGRAMS

Thematic programs bring together hundreds of researchers from around the world to work on specific themes at the cutting edge of mathematical research. They participate in workshops, conferences, mini-courses, or schools. The long-term programs usually last between four months and one year. They also include extended stays of visiting researchers at the CRM as well as lectures given by the Aisenstadt Chairholders.

For the long-term programs, the two themes selected in 2016–2017 were Probabilistic Methods in Geometry, Topology and Spectral Theory (August–December 2016) and Algebra and Words in Combinatorics (March–July 2017).

A short program focused on Causal Statistical Inference and Its Applications to Genetics (July–August 2016).

Thematic Programs

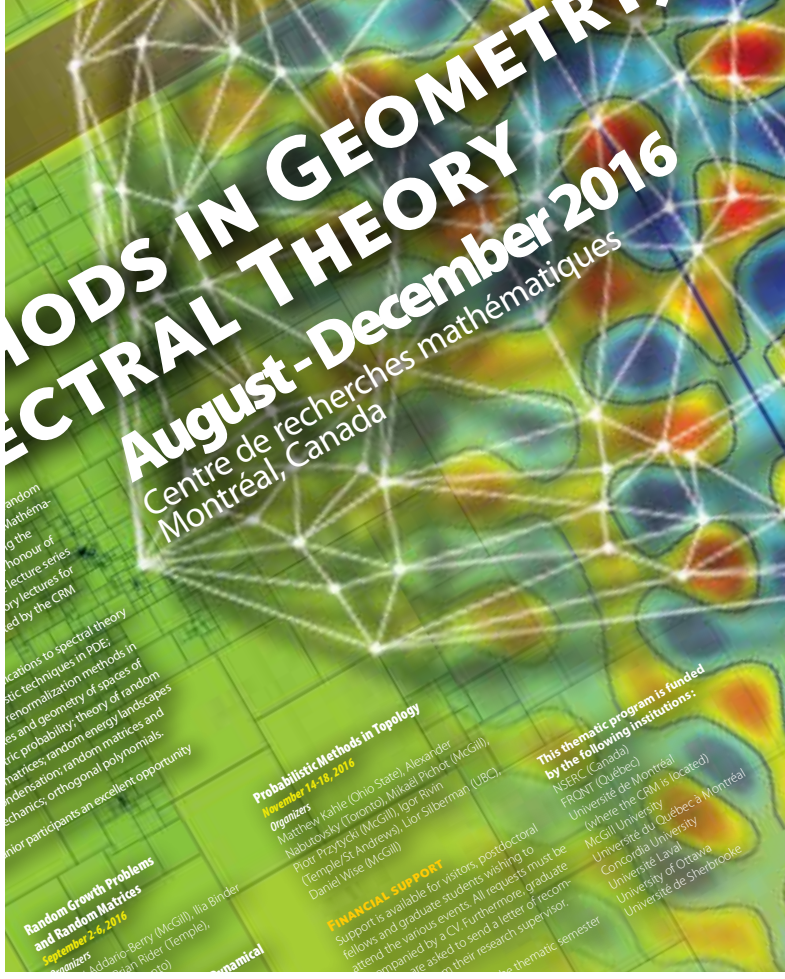
Probabilistic Methods in Geometry, Topology and Spectral Theory

August–December 2016

Probabilistic methods have played an increasingly important role in many areas of mathematics, from the study of random groups and random simplicial complexes in topology, to the theory of random Schrödinger operators in mathematical physics. The Centre de recherches mathématiques organized an intensive Thematic Program on Probabilistic Methods in Geometry, Topology, and Mathematical Physics during the period of August–December 2016. The program was comprised of five intensive one-week workshops, including a workshop in honour of Barry Simon; the latter was preceded by a Young Researchers Symposium held at the Fields Institute. In addition lecture series were delivered by three Aisenstadt Chairholders: Nalini Anantharaman, Yuval Peres, and Scott Sheffield. The workshops were preceded by preparatory lectures for advanced graduate students. Numerous long-term visitors and postdoctoral researchers participated in the program: they were hosted by the CRM Mathematical Analysis Laboratory and the CRM Probability Laboratory.

This thematic program covered a wide range of topics, including geometric analysis on manifolds of metrics and applications to spectral theory and quantum chaos; geometry of random metrics and related problems in quantum gravity; applications of probabilistic techniques in PDEs; eigenstate localization in random domains; probabilistic results in number theory; geometry of Teichmüller spaces; renormalization methods in dynamical systems; random variational problems; dynamical systems methods in PDE; random simplicial complexes and geometry of spaces of triangulations and connections to geometric group theory, manifold learning, topological statistics, and geometric probability; theory of random groups and their properties; probabilistic methods in 3-manifold theory; random growth problems and random matrices; random energy landscapes and their connections to stochastic PDEs and to integrable discrete models (such as TASEP); Bose–Einstein condensation; random matrices and random Schrödinger operators; dynamical systems and quasi-periodic operators; many-body quantum mechanics; and orthogonal polynomials.

The thematic semester featured an emphasis on interconnections and cross-fertilization of ideas between these topics, giving junior participants an excellent opportunity to learn from and interact with experts in several different fields.



Workshop: Probabilistic Methods in Spectral Geometry and PDE

August 22–26, 2016, Université de Montréal

Organizers: *Yaiza Canzani (Harvard), Linan Chen (McGill), Dmitry Jakobson (McGill), Armen Shirikyan (Cergy-Pontoise), Lior Silberman (UBC), John A. Toth (McGill)*

The workshop brought together some of the leading researchers in quantum chaos, semi-classical theory, ergodic theory and dynamical systems, partial differential equations, probability, random matrix theory, mathematical physics, conformal field theory, and random graph theory. Its emphasis was on the use of ideas and methods from probability in different areas, such as quantum chaos (study of spectra and eigenstates of chaotic systems at high energy); geometry of random metrics and related problems in quantum gravity; solutions of partial differential equations with random initial conditions. The workshop was part of a series of related workshops held at the CRM and elsewhere, including a workshop on infinite-dimensional geometry (MSRI, December 2013), a workshop on the geometry of eigenvalues and eigenfunctions, and a workshop on manifolds of metrics and probabilistic methods in geometry and analysis (both held at the CRM in 2012). Many of the workshop talks concerned delocalization (equidistribution) of eigenfunctions at high energy, or the so-called quantum ergodicity. In particular this was the main topic of Nalini Anantharaman's Aisenstadt lectures.

The first day of the workshop was devoted to the study of "random" eigenfunctions. B. Hanin discussed the scaling of harmonic oscillator eigenfunctions and their nodal sets, in both allowed and forbidden regions, as well as around the caustic. I. Wigman discussed the number of nodal intersections of random Gaussian Laplace eigenfunctions on the standard 2-dimensional flat torus with a fixed reference curve. The expected intersection number is universal; Wigman described the variance for generic smooth curves in the high energy limit. A. Taylor discussed vortex knotting in random quantum eigenfunctions. Random complex-valued eigenfunctions in three dimensions are known to have fractal properties at large scales, although more subtle topological quantities such as the probability of knotted or linked vortices are sensitive to the details of the model. Taylor also discussed numerical results for knot probabilities in three random systems (3D cube, 3-sphere, and 3D harmonic oscillator); one of the conclusions was that knots tend to occur with high probability even at comparatively low energies. D. Gayet discussed percolation of random nodal lines. The day concluded with the first Aisenstadt lecture by N. Anantharaman.

On the second day of the workshop, H. Hezari discussed applications of small-scale quantum ergodicity to the study of various quantities associated with eigenfunctions, such as the L_p norm, the size of nodal sets, the order of vanishing, growth estimates, and the inner radius of nodal domains. In the next talk V. Cammarota described results about critical points of random spherical harmonics, describing their limiting distribution and the asymptotic fluctuations. Her results require a careful investigation of the validity of the Kac–Rice formula in nonstandard circumstances. She also presented some recent results on the spatial distribution of critical points of random plane waves. M. Rossi spoke about nodal sets of random high-energy eigenfunctions on arithmetic 2-tori; in particular the distribution of the nodal length converges to a non-universal (non-Gaussian) limiting distribution, depending on the angular distribution of lattice points on the corresponding circle. Rossi also described her results on intersections of nodal lines.

G. Rivière spoke about delocalization of solutions of the Schrödinger equation on Zoll manifolds, for both stationary and non-stationary solutions. He gave criteria on the Zoll metric and on the potential under which these solutions cannot concentrate on a given closed geodesic. J. Galkowski spoke about his construction of arbitrarily small (in the operator norm topology) perturbations of Dirichlet Laplacians that are quantum uniquely ergodic. The method of proof is largely probabilistic. The day concluded with the second Aisenstadt lecture by N. Anantharaman.

The third day began with a talk by A. Komech on the foundation of the equilibrium statistical physics and the long-time convergence to equilibrium measures for Hamiltonian PDEs. After discussing the history of the problem (going back to the work of Boltzmann and Zermelo), as well as previous work for translation-invariant measures, Komech focused on his work with Dydnikova, Spohn, Kopylova, and Suhov on non-translation-invariant initial measures. Examples include wave and Klein–Gordon equations, harmonic crystal, and other problems. Methods used in this work include oscillatory integral representation for solutions of equations with constant coefficients; convergence of correlation functions and convergence of characteristic functionals; Bernstein's room-corridor method and Ibragimov–Linnik central limit theorem; and scattering theory.

I. Goldsheid spoke about properties of Lyapunov exponents of the product of independent non-identically distributed random matrices and related localization problems of random Schrödinger operators on a strip. F. Klopp spoke about interacting electrons in a random background. He considered the d-dimensional Schrödinger operator with a repulsive Poisson random potential, and n interacting electrons located in this random background and restricted to a cube of side length L. He studied the limit of the ground state and of the ground state energy (per particle) of this quantum system when n and L go to infinity in such a way that $n/(LD)$ converges to a fixed positive density; he described some preliminary results.

In the afternoon, Z. Rudnick spoke on his joint work with Blomer, Bourgain, and Radziwiłł on small gaps in the spectrum of the Laplacian on the rectangular billiard having irrational squared aspect ratio, in comparison with the corresponding quantity for a Poissonian sequence. He discussed results that are consistent with Poisson statistics, and relations to the properties of the Fibonacci sequence. He also presented related results for a set of aspect ratios of full measure, and deviations from strict Poisson statistics. S. Nonnenmacher talked about joint work with M. Vogel on random perturbations of non-self-adjoint operators, extending the spectral analysis of semi-classical non-self-adjoint operators subject to a small random perturbation. Nonnenmacher investigates the correlations between the eigenvalues at microscopic distances. For 1-dimensional operators, these correlations still enjoy a form of universality, where the central object is the Gaussian Analytic Function, introduced by Hannay in the context of quantum chaos and originally designed to describe chaotic eigenfunctions. The day concluded with the last Aisenstadt lecture by N. Anantharaman.

The first two talks on the fourth day of the workshop were devoted to rigorous results in Liouville conformal field theory on Riemann surfaces. R. Rhodes presented the first rigorous (probabilistic) construction of Liouville CFT on Riemann surfaces. This construction yields non trivial CFTs. Rhodes derived some of their fundamental properties such as conformal covariance under PSL action, the KPZ scaling laws, the KPZ formula, and the Weyl anomaly (Polyakov–Ray–Singer) formula. The constructions (resulting from joint work with David, Kupiainen, Lacoin, and Vargas) are based on Polyakov's path integral (1981) and on the mathematical side on Kahane's 1985 Gaussian multiplicative chaos theory. In the second talk on Liouville CFT, V. Vargas discussed a rigorous derivation of Ward and Belavin–Polyakov–Zamolodchikov identities for the Liouville CFT on the Riemann sphere. These identities are the basis for computing the correlations and establishing the correspondence between the Feynman path formalism of Liouville CFT and the algebraic formalism based on the Virasoro algebra.

S. Klevtsov discussed geometry and large N limits in Laughlin states that explain the fractional Quantum Hall effect. Considering Laughlin states on Riemann surfaces allows one to elucidate novel quantized coefficients in QHE, hidden for the planar geometry. This problem makes use of methods in Kähler geometry, local index theorems, geometric analysis on singular Riemann surfaces, as well as $2d$ quantum field theory. E. Schippers talked about Quasiconformal Teichmüller theory as an analytic foundation for CFT. The underlying geometric category of two-dimensional CFT is the moduli space of Riemann surfaces with parametrized boundaries, and the sewing operation. Schippers, together with D. Radnell, showed that this moduli space can be identified (up to a discrete group action) with quasiconformal Teichmüller space. This result led to other results (obtained with D. Radnell and W. Staubach) providing an analytic foundation for two-dimensional CFT.

R. Chang discussed quantum ergodicity results (generalizing those of VanderKam, Zelditch et al.) for Wigner induced random spherical harmonics. Chang works with a more general notion of randomness by replacing Haar measures with measures induced by generalized Wigner matrices. Using Bourgade–Yau's theorem on asymptotic normality of generalized Wigner eigenvectors, he is able to show that this Wigner induced construction almost surely yields random spherical harmonics that are quantum ergodic. In the last talk on Thursday, E. Kopylova spoke on asymptotic stability of moving kinks for the relativistic Ginzburg–Landau equation: starting in a small neighbourhood of a kink, the solution, asymptotically in time, is the sum of a uniformly moving kink and a dispersive part described by the free Klein–Gordon equation.

The last day of the conference began with the talk by E. Le Masson, in which he described his joint work with T. Sahlsten on quantum ergodicity and Benjamini-Schramm convergence of hyperbolic surfaces, mentioned in N. Anantharaman's lectures. He presented an alternative equidistribution theorem for eigenfunctions where the eigenvalues stay bounded and one takes instead a sequence of compact hyperbolic surfaces converging to the plane in the sense of Benjamini and Schramm. The proof presented differs in important ways from the usual proof of quantum ergodicity: in particular it does not utilize any microlocal analysis. The workshop concluded with a talk by P. Bourgade, where he surveyed several recent results on spectra and eigenvectors of Wigner matrices, obtained in a series of joint articles with Erdős, H.-T. Yau, Yin; he also surveyed the results due to Erdős–Schlein–Yau and Tao–Vu. The techniques include the study of Dyson Brownian motion, the associated eigenvector dynamics, and the study of a related problem describing a random walk in a random environment. Bourgade also discussed related questions about random band matrices, and conjectures due to Fyodorov and Mirlin.

Overall the workshop was a great success. Many talks were given by young researchers (recent PhDs and even graduate students). A semester-long course related to the theme of the workshop was taught by two of the organizers (L. Chen and D. Jakobson) in the Fall of 2016.

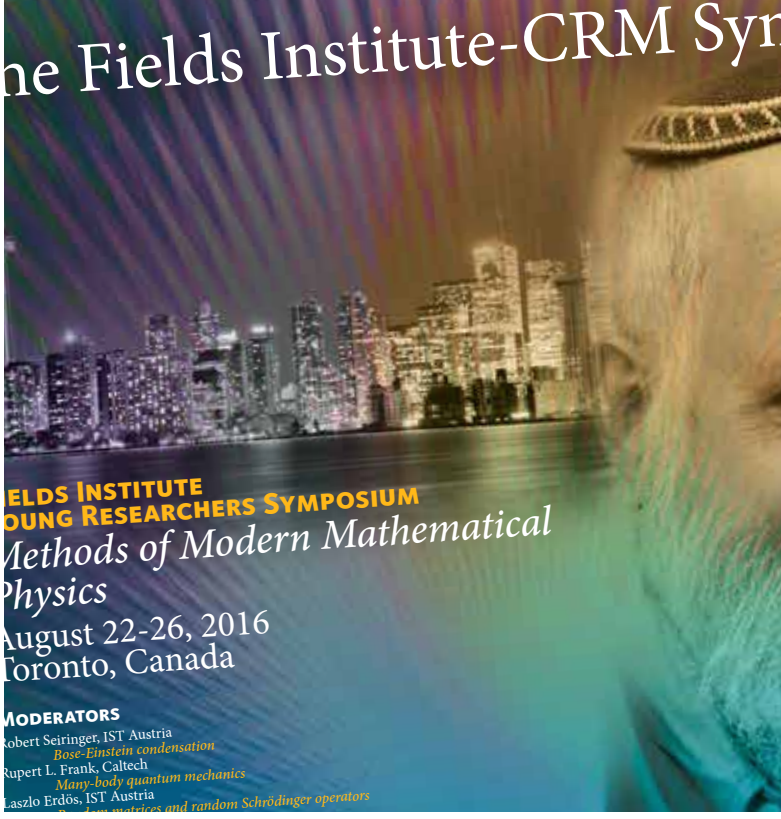
Frontiers in Mathematical Physics In Honour of Barry Simon's 70th Birthday

August 28–September 1st, 2016, Université de Montréal

Sponsored by the following institutions: CRM, Fields Institute, AIHPD, Caltech, IAMP, AIP, AMS, NSF, Springer, and Cambridge University Press

Organizers: *Jonathan Breuer (Hebrew), Walter Craig (McMaster), Percy Deift (Courant Institute, NYU), George A. Hagedorn (Virginia Tech), Svetlana Jitomirskaya (UC, Irvine), Andrei Martinez–Finkelshtein (Almería)*

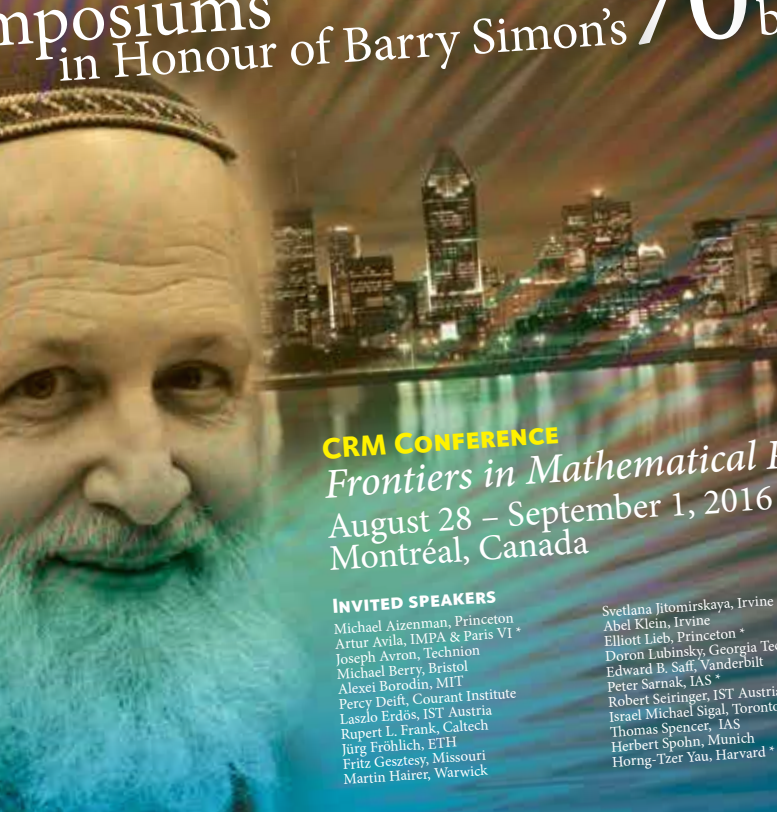
Two consecutive events took place in Toronto and Montreal in August 2016, as part of Barry Simon's 70th birthday celebration. Professor Simon is one of the founding fathers of modern mathematical physics. His interests span a vast number of topics and his influence, through research papers, books, and mentoring skills, is felt in many areas of mathematics. He has made significant contributions over the years to quantum field theory, statistical mechanics, Schrödinger operators, the theory of orthogonal polynomials, and the list is not complete.



First, honouring his remarkable dedication to the advancement of young mathematical physicists, a Young Researchers Symposium on "Methods of Modern Mathematical Physics" covering several areas of mathematical physics took place at the Fields Institute in Toronto, on August 22–26, 2016. There were 120 registered participants, most of whom were students, postdocs, and junior faculty members from all over the world.

Diverse topics were covered in five days. The opening talks were given by scientific leaders, who also acted as moderators, and were mostly of an introductory character. The topics and moderators (Monday to Friday schedule) matched some of the fields of interest of Barry Simon, mentioned above: Bose–Einstein condensation (Seiringer, IST Austria), many-body quantum mechanics (Frank, Caltech), random matrices and random Schrödinger operators (Erdős, IST Austria), orthogonal polynomials (Christiansen, Lund), and spectral theory of quasi-periodic operators (Jitomirskaya, UC Irvine).

There were two one-hour lectures on Mathematical Methods in Many-Body Quantum Mechanics (Lewin, CNRS & Université Paris-Dauphine), and three "Short Introductions," respectively on random matrices (Erdős, IST Austria), orthogonal polynomials (Christiansen, Lund University), and quasi-periodic dynamics (Jitomirskaya, UC Irvine). These opening lectures were especially helpful for non-specialists: they enabled them to follow the approximately 40 talks by junior researchers and a discussion of open problems.



Many of the participants at the Toronto meeting also attended the second event, a conference on "Frontiers in Mathematical Physics" that took place at the CRM in Montreal the following week. This time the goal was to bring together leading researchers in mathematical physics, with the purpose of outlining recent advances and new directions of research. There were a total of 160 registered participants. Some of the moderators at the Toronto meeting gave talks, together with other researchers representing several fields; altogether there were 19 invited speakers. Many of them took advantage of their talks to tell some stories featuring Professor Simon. More stories were told during the conference banquet.

The talks spanned again the broad spectrum (pun intended) of Barry Simon's interests. There was some mathematical physics (Fröhlich, Sigal, Klein, Frank, Lieb, Seiringer), random matrices and stochastic processes (Yau, Erdős, Hairer, Borodin, Spohn, Deift, and Spencer), spectral theory (Gesztesy, Jitomirskaya), and orthogonal polynomials (Lubinsky, Martínez-Finkelshtein).

Although the schedule of lectures was dense, there were no parallel sessions, which allowed the participants to attend any lecture they wished. Barry Simon attended all the lectures from both conferences, actively contributing with questions and remarks.

Workshop
Random Growth Problems and Random Matrices
September 2–5, 2016, CRM

Organizers: *Louigi Addario-Berry (McGill), Ilia Binder (Toronto), Bálint Virág (Toronto)*

This workshop followed on the heels of Barry Simon's 70th birthday conference. The first day of the conference featured public lectures by two Aisenstadt chairs, Scott Sheffield and Yuval Peres. Sheffield presented an overview of his recent breakthrough work on random planar structures and their scaling limits. In the last five years, he and his collaborators and students have built a powerful theory of random surfaces, uncovering connections and proving relations between a vast range of fundamental probabilistic objects such as the Schramm–Loewner evolution, Liouville quantum gravity, the Gaussian free field, and the Brownian map. His lecture also included an introduction to the Yang–Mills problem and its connection with random matrix theory and random maps.

Peres presented work on a variety of planar growth models, including the abelian sandpile model, rotor walks, and internal diffusion limited aggregation. The abelian sandpile model (Bak–Tang–Wiesenfeld, 1987 and Dhar, 1990) has only a tenuous connection to real sandpiles but it has intriguing connections to a wide variety of mathematical subjects, including: combinatorics, free boundary PDEs, and tropical algebraic geometry. Peres explained his recent results on limit shapes, conformal invariance properties, and fluctuations of the boundary for these models.

Several speakers (Sosoe, Damron, Hoffman) discussed first-passage percolation and its variants. One of the obstacles in the study of first-passage percolation (FPP) that has stumped the field is how to describe the limit shapes for FPP as a function of the edge weights. The challenge is captured by a theorem of Haggstrom and Meester: for any symmetric convex set B in R^2, there is an ergodic weight measure on the edges of the lattice Z^2 such that first-passage percolation with these weights has B as a limit shape. Thus, to limit the possible shapes B can take in IID percolation, one must exploit independence, and to date we do not know how.

In fact, the situation is even worse. One open problem posed by Benjamini, Kalai, and Schramm can be stated as follows. Give the edges of Z^2 IID positive continuous weights. Let P be the shortest path from $(-n,-n)$ to (n,n). Is it the case that Prob(0 is in P) tends to zero as n tends to infinity? We believe that this probability in fact decays polynomially with n, but even a proof of the weaker assertion has been elusive. Hoffman presented his extremely recent proof that the probability indeed tends to zero; this is quite a breakthrough.

Another major theme, as suggested by the title, was random matrices, with presentations by Rider, Lytova, and Bourgade. A famous conjecture from probabilistic combinatorics is that if $M(n,d)$ is the adjacency matrix of a random d-regular graph sampled according to the configuration model, then $P(\text{rank}(M(n,d)) < n)$ tends to zero with n. Lytova presented her recent proof that this holds for directed graphs provided $d=d(n)$ tends to infinity. Bourgade gave a probabilistic intuition for the phase transition between localization and delocalization in random band matrices. He explained the Erdős–Schlein–Yau approach to universality for random matrix ensembles via the Ornstein–Uhlenbeck flow. He concluded with a brief overview of the connection with the delocalization phase for the Anderson model, and in particular the Fyodorov–Mirlin conjecture. Rider presented his universality result for the matrix hard edge, and gave a pellucid description of how proving such results can be boiled down at an intuitive level to proving a classical central limit theorem.

Among the other topics addressed by the speakers were: conformally invariant discrete growth models, scaling limits for random trees, and competition interfaces in branching and annihilating random walks, large deviations for random projections, and variational principles for mean-field spin glasses. On the final day, Chatterjee gave an outstanding lecture describing his rigorous derivation of the $(1/N)$ expansion for $SO(N)$ lattice gauge theories. We expect that this line of research, which involves developing rigorous methods for taking averages over the trajectories of random strings, will soon be recognized as one of the most remarkable recent developments in rigorous mathematical physics.

Participants were uniformly effusive about the conference; it kept the CRM and Montreal on the map for several highly dynamic and exciting areas of research in probability and its interfaces with the physical sciences.

.

Workshop
Probabilistic Methods in Dynamical Systems and Applications
October 4–7, 2016, CRM

Organizers: *Dmitry Dolgopyat (Maryland), Dmitry Jakobson (McGill), Konstantin Khanin (Toronto)*

This workshop focused on several topics, including probabilistic results in number theory, renormalization methods in dynamical systems, random variational problems, and dynamical systems methods in PDEs. On October 4, the first speaker was Y. Bakhtin, who spoke about his results (joint with E. Cator, K. Khanin, and L. Li) on the ergodic theory of the Burgers equation with random forcing. He also talked about the ergodic theory of the randomly forced Burgers equation in a non-compact setting. The basic objects are one-sided infinite minimizers of random action (in the inviscid case) and polymer measures on one-sided infinite trajectories (in the positive viscosity case). The next talk was given by A. Boritchev, who spoke about the exponential convergence and hyperbolicity of the minimizers for random Lagrangian systems. In a joint work with K. Khanin, he considered the stochastic Burgers equation from the Lagrangian point of view (long-time behaviour of the minimizers) as well as from the point of view of the statistical behaviour of the solutions (long-time convergence towards the stationary measure). In both cases there is a phenomenon of exponential convergence.

The first speaker on October 5 was Jayadev Athreya, who spoke about the Erdős–Szüsz–Turán and Kesten distributions for equivariant point processes. In a joint work with A. Ghosh, he showed how number-theoretic problems posed by Erdős–Szüsz–Turán and Kesten about the probability of improving Dirichlet's theorem can be solved and generalized using ideas from dynamical systems. The next talk was given by J. Chaika, who spoke about disjointness for 3-interval exchange transformations (3-IET). In a joint work with Alex Eskin, he showed that the distinct positive powers of a typical 3-IET are not isomorphic and in fact satisfy a stronger property (i.e., they are disjoint). He also showed that most of the positive powers of any 3-IET satisfying a mild diophantine assumption are disjoint. This implies that such a 3-IET is disjoint from the Möbius μ function, verifying a conjecture of Sarnak for these systems. The third talk of the day was given by M. Avdeeva, who spoke about a central limit theorem for a B-free dynamical system. She presented a new Central Limit Theorem for such a system under certain additional arithmetic conditions on the underlying set B.

The first talk in the afternoon was given by A. Dembo, who spoke about the Atlas model, in and out of equilibrium. In joint works with L.-C. Tsai, M. Cabezas, A. Sarantsev, and V. Sidoravicius, he showed that for the equilibrium density (L=2), the asymptotic Gaussian space–time particle fluctuations are governed by the stochastic heat equation with Neumann boundary conditions at zero. As a by-product, they solved a conjecture of Pal and Pitman (2008) about the asymptotic (random) fBM trajectory of the Atlas particle. In a complementary work, Dembo derived and explicitly solved the Stefan (free-boundary) equations for the limiting particle-profile when starting at out-of-equilibrium density (L other than 2), thus determining the corresponding (non-random) asymptotic trajectory of the Atlas particle. The last talk on October 5 was given by M. Lyubich, who spoke about wild attractors, Julia sets of positive area, and RG random walks. A "wild attractor" is a proper compact invariant subset that attracts almost all orbits of a topologically transitive dynamical system. Wild attractors, although quite rare, can appear in both real and complex dynamics. M. Lyubich gave an overview of the circle of problems related to wild attractors.

The first speaker on October 6 was A. Brown, who spoke on Zimmer's conjecture for cocompact lattices. Zimmer's conjecture states that for $n > 2$, any just action by diffeomorphisms of a lattice in $SL(n,R)$ on a compact manifold M factors through the action of a finite group if the dimension of M is at most $n-2$. Moreover, any volume-preserving action should factor through the action of a finite group if the dimension of M is at most $n-1$. In a joint work with D. Fisher and S. Hurtado, Brown showed that Zimmer's conjecture holds for actions of cocompact lattices. He recovered the full conjecture for cocompact lattices in symplectic and split-orthogonal groups. The next talk was given by A. Gogolev, who spoke about his work with F. Rodriguez Hertz on blow-ups of partially hyperbolic diffeomorphisms. He explained how the blow-up construction can be used to produce new examples of partially hyperbolic dynamical systems by "blowing-up" existing examples. The last speaker in the morning was F. Rodriguez Hertz, who spoke about joint work with A. Kanigowski and K. Vinhage on examples of volume-preserving transformations of the 4-torus that have the K (Kolmogorov) property but are not Bernoulli.

V. Jakšić gave the first talk of the afternoon, actually the first in a sequence of two talks on entropic fluctuation relations and large deviations; the second talk was given on Friday by Armen Shirikyan. Jakšić described the structural theory of entropic fluctuation relations (Gallavotti–Cohen, Evans–Searles), emphasizing the role of the large deviations theory. The talk was based on the joint works with V. Nersesyan, C.-A. Pillet, A. Shirikyan, and M. Porta and was attended by a large group of students working in Mathematical Physics. The last talk of the afternoon was given by Y. Kifer, who spoke about a functional Erdős–Rényi law of large numbers for nonconventional sums, i.e., sums of terms of the form $F(X_m, X_{2m}, ..., X_{lm})$ (where X_j is a sequence of exponentially fast ψ-mixing random vectors and F is a Borel vector function).

The first speaker on October 7 was L. Koralov, who spoke about metastable distributions of Markov chains with rare transitions and related problems resulting in differential equations with nonstandard boundary conditions. In a joint work with M. Freidlin and A. Wentzell, he considered Markov chains with parameter-dependent transition rates. The asymptotic behaviour of the Markov chains was established at various time scales related to the value of the parameter. This result can be viewed as a generalization of the ergodic theorem to the case of parameter-dependent Markov chains. It can be applied in the study of randomly perturbed dynamical systems (i.e., diffusion processes with a small diffusion coefficient). In this case, each asymptotically stable equilibrium of the dynamical system can be associated with a state of a Markov chain. He described the asymptotic behaviour of a diffusion process with multiple trapping regions (with the vector field equal to zero outside the regions) in terms of a PDE with nonstandard boundary conditions.

Koralov's talk was followed by that of A. Shirikyan, who gave the second part in a sequence of talks begun by Jakšić. Shirikyan considered some concrete models for which one can carry out the analysis outlined in Jakšić's talk. The main emphasis was on the problem of large deviations for randomly forced PDEs. He also discussed the Gallavotti–Cohen symmetry and the positivity of the mean entropy production. J. De Simoi delivered the last talk of the workshop: he spoke about the decay of correlations in fast–slow partially hyperbolic systems. In a joint work with C. Liverani, he showed the existence of an open class of partially hyperbolic smooth local diffeomorphisms of the two-torus admitting a unique SRB measure satisfying exponential decay of correlations. He also obtained realistic estimates for the rate of decay of correlations.

The workshop brought together some of the leading researchers working in probability, dynamical systems, ergodic theory, mathematical physics, PDEs, and number theory. Numerous questions were raised after each talk and many lectures were given by young researchers. The workshop was a resounding success.

Workshop
Probabilistic Methods in Topology
November 14–18, 2016

Organizers: *Dmitry Jakobson (McGill), Matthew Kahle (Ohio State), Alexander Nabutovsky (Toronto), Mikaël Pichot (McGill), Piotr Przytycki (McGill), Igor Rivin (St Andrews), Lior Silberman (UBC), Daniel T. Wise (McGill)*

This workshop brought together researchers working on: random simplicial complexes and geometry of spaces of triangulations (with connections to manifold learning); topological statistics and geometric probability; the theory of random groups and their properties; random knots; random graphs; and other topics.

Matthew Kahle gave a series of three introductory lectures during the workshop (on Monday, Wednesday, and Friday, respectively). In the first one ("An invitation to stochastic topology"), he discussed random manifolds and random knots and then focused on random simplicial complexes (particularly the Linial–Meshulam random 2-complex), giving an overview of a number of phase transitions for the latter model. In his second lecture ("A brief survey of random finitely-presented groups"), Kahle introduced three models of random groups: the Gromov density model, the triangular model, and the random fundamental group. He also discussed their most fundamental properties, such as hyperbolicity, Kazhdan Property (T), and cohomological dimension. Kahle's third lecture ("Maximally persistent cycles in random geometric complexes") was based on his article with O. Bobrowski and P. Skraba: he first talked about the size of the maximal component for random geometric graphs in various regimes. A question raised by M. Gromov led to a discussion about relations to critical percolation and possible analogues in higher dimensions. Kahle ended his lecture by describing his recent results on persistence of the largest cycles.

The conference began on Monday with a talk by I. Rivin on several models of random knots, their geometry, and other characteristics. Rivin presented the results of several computer experiments on random "Fourier" knots, their regularity, crossing number, and the distribution of coefficients and zeros of the corresponding Alexander polynomials. He also discussed analogous results for the random spherical chord model of the knots and concluded with several open problems. His talk led to lively exchanges and Rivin continued comparing experimental results (generated on the spot!) with Giulio Tiozzo, Chaim Even-Zohar, and others. In the second talk on Monday, T. Odrzygozdz introduced the square and hexagonal random group models, which are generalizations of Zuk's triangular model: he gave motivations for these models and presented what is already known (e.g. in the hexagonal model there is a sharp threshold for Property (T) at 1/3). Then P. Bubenik gave a talk on his joint work with P. Bendich on probabilistic persistent homology: he showed how the probabilistic point of view allows one to obtain a stable summary of the critical faces in persistent homology. The last talk on Monday was the Kahle's lecture mentioned above.

The first talk on Tuesday was given by L. Addario-Berry and focused on the probabilistic analysis of the minimum spanning tree (MST) problem. The structure of a random MST in a graph G turns out to be intimately linked to the behaviour of critical and near-critical percolation on G. Addario-Berry described this connection and some results on the structure, scaling limits, and volume growth of random MSTs. It turns out that, in high-dimensional graphs, random MSTs are expected to be three-dimensional when viewed intrinsically, and six-dimensional when viewed as embedded objects. The next talk was delivered by A. Abu Fraiha, who spoke about random simplicial complexes based on Steiner systems. Following the work of Linial and Meshulam, he introduced a model for random complexes with bounded degree and studied its topology. He used spectral gap theory (particularly Garland's method) to show homological connectivity of these random complexes and gave an upper bound on Betti numbers of complexes with highly connected links.

The third talk of the day was given by O. Bobrowski, who reviewed advances in the study of the homology of random geometric complexes. He focused on phase transitions related to the appearance and vanishing of homology and the limiting distributions for the Betti numbers of these complexes. He reviewed models for generating a random geometric complex and discussed their similarities and differences. In the first afternoon talk J. Behrstock spoke on new threshold theorems for random graphs, motivated by ideas in geometric group theory (recall that in the Erdős–Rényi model, there is a sharp threshold at which low-density random graphs are disconnected and high-density graphs are connected). Then Behrstock gave applications of these results to the geometry of Coxeter groups. The last speaker on Tuesday was G. Tiozzo, who spoke about the counting of loxodromic elements for hyperbolic actions. Given a hyperbolic group G acting on a hyperbolic metric space X, a loxodromic element of G is an element acting as a loxodromic isometry of X. Tiozzo showed that for any finite generating set of G, the proportion of loxodromic elements in the ball of radius n about the identity in G approaches 1 as n tends to infinity. He also established several results about the behaviour in X of the images of typical geodesic rays in G.

On Wednesday the first speaker was C. Even-Zohar, who spoke about random knots. Random curves in space and how they are knotted give an insight into the behaviour of "typical" knots and links. They have been studied by biologists and physicists in the context of the structure of random polymers. Even-Zohar and his co-authors (Hass, Linial, and Nowik) studied random knots based on petal projections and found explicit formulas for the limit distribution of finite type invariants of random knots and links in the Petaluma model. Even-Zohar's talk, together with Rivin's talk on Monday, gave a very good overview of some state-of-the-art results about random knots; this led to several stimulating exchanges during the workshop. In the following lecture J. Maher spoke on strata of random mapping class group elements. A random walk on the mapping class group of a surface yields a pseudo-Anosov element with a probability tending to 1 as the length of the walk tends to infinity. Maher showed that the probability that such a pseudo-Anosov element has an invariant axis lying in the top-dimensional strata also tends to 1, and in particular the stable and unstable foliations have generic trivalent singularities.

The third speaker on Wednesday was M. Chas, who spoke on several numbers associated with a free homotopy class X of closed curves on a surface with boundary and negative Euler characteristic: the self-intersection number of X; the word length of X; the length of the geodesic in X; and the number of free homotopy classes of a given word length in the mapping class group orbit of X. The interrelations of these numbers exhibit many patterns when computed explicitly or approximated through diverse algorithms running on a computer; they led to counterexamples to certain conjectures and the discovery of new patterns and theorems. One of the counterexamples is that there exist pairs of length-equivalent free homotopy classes of curves on a surface S that have distinct self-intersection numbers. One of the theorems discovered states that the distribution of the self-intersection of free homotopy classes of closed curves on a surface, appropriately normalized, sampling among those of a given word length, approaches a Gaussian when the word length tends to infinity.

The first lecture on Wednesday afternoon was given by S. Antoniuk, who presented her joint work with E. Friedgut and T. Luczak on random triangular groups. She considered a random group model given by a random presentation with relators of length three, each chosen independently with a given probability. She investigated the threshold for collapsing to a trivial group and showed that this threshold is sharp (using a method of Friedgut). The next speaker was B. Lishak, who spoke on the space of triangulations of a compact 4-manifold. The number of triangulations of a compact 4-manifold grows at least exponentially as a function of the number of simplices. Furthermore, if one defines the distance between two triangulations as the minimal number of Pachner moves needed to go from one triangulation to another, one can make sure that the distance between any pair of triangulations in a certain exponential set of triangulations is larger than the tower of exponents of a fixed height. This result follows from a similar result about balanced presentations of the trivial group. The last speaker on Wednesday was Matt Kahle, who gave his second lecture (see the beginning of this report).

On Thursday the first two lectures dealt with random simplicial complexes (RSCs). M. Farber described a multi-parameter model of RSCs that includes the Linial–Meshulam RSCs and random clique complexes as special cases. The topological and geometric properties of such an RSC depend on the combination of the probability parameters and the thresholds for topological properties are convex sets rather than numbers. Farber discussed the containment properties, density domains, and dimension of these RSCs. In the next talk Y. Peled spoke about his joint work with Linial on higher-dimensional analogues of the phase transition results for the Erdős–Rényi random graph model. He discussed the threshold probabilities for d-collapsibility and vanishing of H_d, the d-Betti number in the non-acyclic regime, and the nature of the phase transition. The third morning talk was given by M. Gromov and was entitled "Can homology replace probability?". Gromov discussed the historical definition of entropy, the "functorial" (or categorical) approach to defining it, and the Fischer entropy. He then discussed ball packing problems and the corresponding action of the permutation group. He asked what part of the geometry of a Riemannian manifold M can be recovered from the information about homology groups of spaces of packings of M using metric balls.

On Thursday afternoon the first speaker was M. Sapir, who showed that a random 1-related group with at least three generators is residually finite and coherent (this is joint work with Iva Spakulova). The next speaker was D. Futer, who presented joint work with D. Wise on cubulated groups. A group is called cubulated if it is the fundamental group of a compact, non-positively curved cube complex. Futer showed that generic quotients of cubulated hyperbolic groups are also cubulated and hyperbolic. In the last talk on Thursday, J. Mackay presented joint work with Cornelia Drutu on why the actions of certain random groups on L_p spaces have fixed points. The workshop ended on Friday with the talk of T. Luczak (who presented joint work with Y. Peled on the threshold when the first homology group over Z of the random simplicial complex becomes trivial), the talk of R. Glebov on virtually fibering random right-angled Coxeter groups (describing joint work with Ilan Karpas and Gonzalo Fiz Pontiveros), and the third lecture by Matt Kahle.

Algebra and Words in Combinatorics

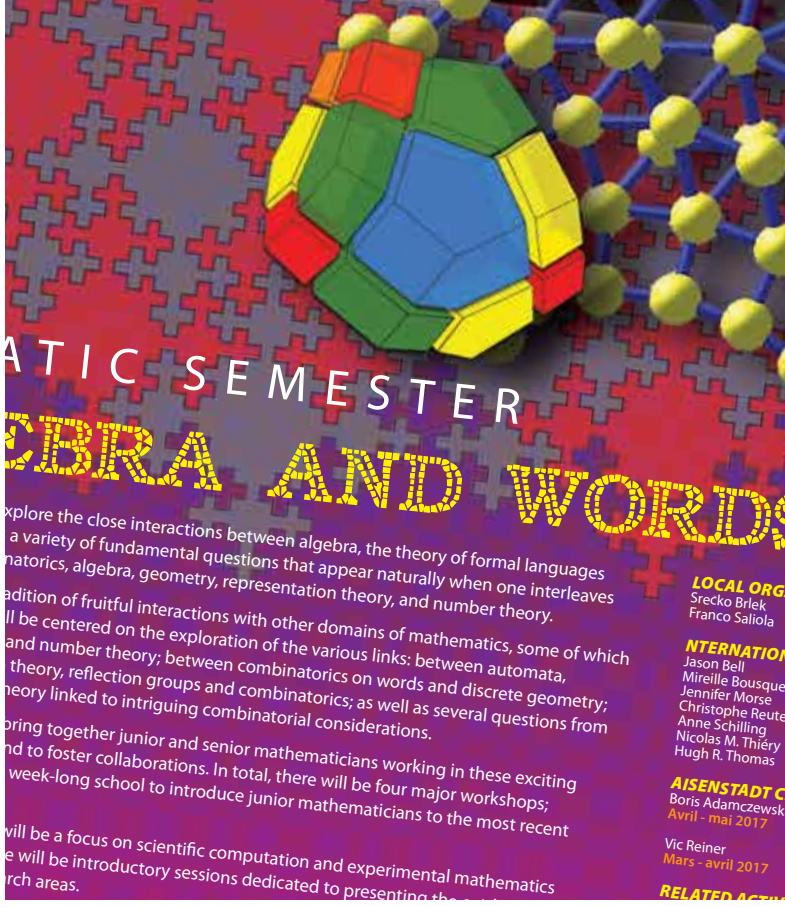
March–July 2017

This thematic semester explored the close interactions between algebra, the theory of formal languages and combinatorics, as well as a variety of fundamental questions that appear naturally when one interleaves principal threads from combinatorics, algebra, geometry, representation theory, and number theory.

Combinatorics has a strong tradition of fruitful interactions with other domains of mathematics, some of which are emerging. The program was centered on the exploration of the various links: between automata, automatic sequences, algebra, and number theory; between combinatorics on words and discrete geometry; between group representation theory, reflection groups, and combinatorics. It was also centered on several questions from algebraic geometry and knot theory linked to intriguing combinatorial considerations.

The aim of the workshops was to bring together junior and senior mathematicians working in these exciting areas, so as to enable them to discuss their research and to foster collaborations. There were four major workshops; each workshop was preceded by a week-long school to introduce junior mathematicians to the most recent developments in these areas.

A central aspect of the program was a focus on scientific computation and experimental mathematics as prominent research tools. There were introductory sessions dedicated to presenting the cutting-edge research tools in the various research areas.



Combinatorics on Words and Tilings

School: March 27–31, 2017
Workshop: April 3–7, 2017, CRM

Organizers: *Alexandre Blondin Massé (UQAM), Srečko Brlek (UQAM), Xavier Provençal (Savoie Mont Blanc)*

The geometry of tilings has a long history going back to antiquity as patterns occurred in architecture (the Alhambra and Alcazar palaces in Spain, for instance) and decorative art (the drawings of Cornelius Escher). The seventeen wallpaper groups provide a classification of the periodic tessellations. In modern times, digital geometry emerged as a research domain dealing with discrete point sets and aiming at transposing notions of classical Euclidean geometry to the digital plane.

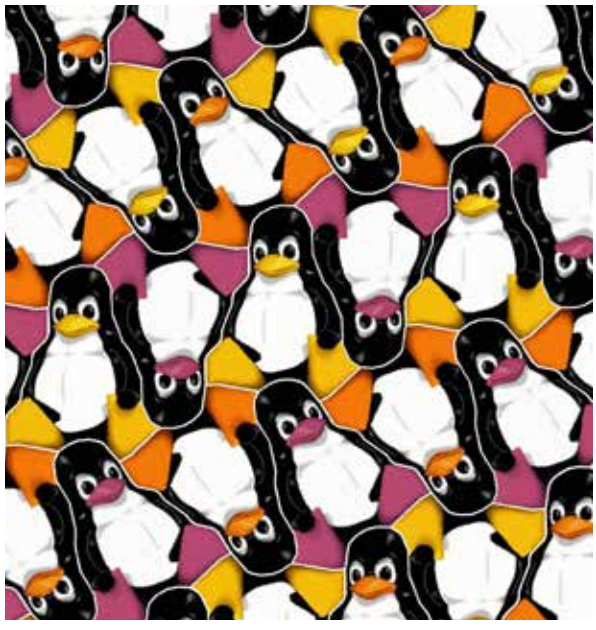
The lecturers for the school were S. Labbé (CNRS, LaBRI) and A. Winslow (University of Texas Rio Grande Valley), two young researchers who delivered dynamic lectures on the problems of monohedral tilings by one polyomino. Labbé presented the Beauquier–Nivat characterization of polyominoes that tile the plane by translations, and in particular those that tile it in two distinct ways. Winslow described some optimal algorithms for recognizing monohedral tilings based on the Beauquier–Nivat characterization, extending the work of X. Provençal. In the case of isohedral tilings he also presented near optimal algorithms.

C. Mann and J. C. McLoud-Mann (University of Washington Bothell) presented their quest of the 15th convex pentagon that tiles the plane isohedrically, 30 years after the discovery of the 14th by R. Stein. M. Rao (CNRS, LIP) delivered a technical lecture on the methods he used for performing an exhaustive search of all convex pentagonal isohedral tilings of the plane. His computer program lists all the fifteen known convex pentagons, ending the speculations about the existence of another one.

The existence of tessellations by Wang tiles has a long history going back to 1961. One of the challenging problems was to classify aperiodic tiles according to tile set size and number of colours. From the negative result of Berger in 1965 (using 20,426 tiles), several improvements have been achieved, including the sets of 14 tiles by J. Kari and 13 tiles by K. Culik II (both presented in 1996).

M. Rao described the exhaustive search performed with a computer program based on a representation of infinite tessellations by (bi)infinite paths in finite transducers. The model proved to be convenient as it enabled him (and E. Jeandel) to prove that 10 tiles or 3 colours are not enough to force aperiodicity. Then it was just a matter of time to find a smaller set of 11 tiles using 4 colours: the exhaustive search of all sets of 11 Wang tiles took one year of computing power on 100 processors. J. Kari (University of Turku) presented an asymptotic version of the well-known 1997 Nivat's conjecture, stating that in dimension $d = 2$ the low complexity assumption for rectangular patterns implies that the tiling is periodic. This constitutes a breakthrough in the field, since we know that the statement does not hold in higher dimensions ($d \geq 3$).

C. S. Kaplan (University of Waterloo) delighted the audience with his artistic approach to tessellations. In the spirit of the work of M. C. Escher, he presented methods for performing the Escherization of arbitrary shapes: more precisely, by mapping an image on a tile that satisfies Conway's Criterion and using convenient deformations, one can produce tilings as this one (source: C. Kaplan's website: http://www.cgl.uwaterloo.ca/csk/projects/).



Bridges between Automatic Sequences, Algebra and Number Theory

School: April 24–28, 2017
Workshop: May 1–5, 2017, CRM

Organizers: *Boris Adamczewski (CNRS, Camille Jordan), Jason Bell (Waterloo), Valérie Berthé (CNRS, IRIF), Sébastien Labbé (CNRS, LaBRI)*

The aim of the school and workshop was to bring together graduate students, postdocs, and senior researchers working in the theory of automatic sequences or in areas that have some strong connection with automatic sequences in order to enable them to discuss their research and foster collaborations. The workshop had a strong focus on the applications of automata and automatic sequences to algebra and number theory. As part of the Aisenstadt Chair of the thematic semester, B. Adamczewski gave a series of lectures on automatic sequences that took place during the two weeks.

The school consisted of mini-courses on topics from combinatorics of words, algebra, and number theory. These mini-courses covered some of the algebraic and number-theoretic background for students and researchers wishing to take part in the workshop. The mini-courses of the school were given by Y. Bugeaud (Strasbourg), C. Reutenauer (UQAM), and R. Yassawi (Paris Diderot). Bugeaud gave a minicourse about links between factor complexity, automatic numbers, transcendence, and Diophantine approximation. Reutenauer described the correspondence between the theory of Markoff numbers and the theory of Christoffel words. Yassawi gave an introduction to automatic sequences, including in particular their links with algebra and number theory. Other talks were given by R. Fokkink (TU Delft), J. Leroy (Liège), N. Rampersad (Winnipeg), E. Rowland (Hofstra), Š. Starosta (CTU Prague), and É. Vandomme (UQAM). Sessions of exercises or computer experiments were also planned, allowing participants to develop intuition for the material of the mini-courses and talks.

As mentioned above, the theory of finite automata naturally interacts, via automatic sequences and automatic sets, with algebra and number theory. Several advances have recently reinforced these deep links. The aim of the workshop was to allow researchers from different areas to meet and exchange ideas about these advances. Here are some of the themes covered by the invited talks: transcendence and Diophantine analysis, arithmetic in positive characteristic, Galois theory of difference and differential equations, logic and model theory, analytic number theory, combinatorics and formal power series, and group theory.

There are many reasons why this meeting was a great success. First of all, we must emphasize its originality, which lies mainly in the diversity of the topics. The presentations focused on areas that were not usually represented in automatic sequences conferences. This is the case, for example, for differential Galois theory and model theory. Another important aspect is that this meeting allowed several young and talented researchers (including doctoral students) like A. Bridy (Texas A&M), T. Dreyfus (Lyon 1), G. Fernandes (Lyon 1), A. Medvedovsky (MPI Mathematik), and C. Müllner (TU Wien) to present their work and thereby participate in the renewal of the community. The momentum of this workshop will undoubtedly contribute greatly to the field and further its development.

Algebraic and Geometric Combinatorics of Reflection Groups

School: May 29–June 2, 2017, UQAM
Workshop: June 5–9, 2017, CRM

Organizers: *Matthew J. Dyer (Notre Dame), Christophe Hohlweg (UQAM), Vincent Pilaud (CNRS, LIX), Hugh Thomas (UQAM)*

The first day of the school was devoted to introductory lectures, for interested participants, on the common background required for the school. The main part of the school (May 30–June 2) consisted of four mini-courses given respectively by C. Bonnafé (Université de Montpellier) on "Representations of rational Cherednik algebras at $q = 0$," P. Przytycki (McGill) on "The isomorphism problem for Coxeter groups," V. Reiner (Aisenstadt Chair, Minnesota) on "Reflection group invariant theory and generating functionology," and N. Reading (North Carolina State) on "Lattice congruences of the weak order."

The following week, the workshop attracted twenty speakers, four per day, in areas including but not limited to the themes of the previous week's School. The themes were combinatorics of Coxeter groups and root systems, complex reflection groups, Artin–Tits groups, hyperplane arrangements and polytopes, representation theory, and geometric group theory. Talks were given by S. Billey (Washington), C. Ceballos (Universität Wien), M. Chlouveraki (Versailles–Saint-Quentin-en-Yvelines), P. Dehornoy (Caen), A. Felikson (Durham), P. Hersh (North Carolina State), K. Jankiewicz (McGill), M. Lanini (Roma Tor Vergata), T. Marquis (UC Louvain), J. McCammond (UC Santa Barbara), K. Mészáros (Cornell), J. Michel (Paris Diderot), Y. Mizuno (Shizuoka), P. Przytycki (McGill), N. Reading (North Carolina State), V. Reiner (Minnesota), V. Ripoll (Wien), S. Stella (Roma La Sapienza), C. Stump (Magdeburg), and J. Swiatkowski (Wroclaw).

Many new collaborations among the participants started during the workshop. Following the success of this meeting, it was decided to hold a similar conference/workshop every two years: the current workshop is thus the first in a series.

Equivariant Combinatorics

School: June 12–16, 2017
Workshop: June 19–23, 2017, Université de Montréal

Organizers: *François Bergeron (UQAM), Luc Lapointe (Talca), Jennifer Morse (Drexel), Franco V. Saliola (UQAM)*

The objective of this workshop, and its associated school, was to explore profound new interactions between algebraic combinatorics, representation theory, algebraic geometry, and knot theory, with interesting ties to theoretical physics.

As is usual for a school–workshop tandem within a thematic semester at the CRM, the aim of the school was to prepare young researchers so that they could properly enjoy the workshop. This was beautifully done by three series of lectures: "Combinatorics of Schubert Calculus" by M. Gillespie (UC Davis); "Algebraic Combinatorics and Representations of Cherednik Algebras" by S. Griffeth (Talca); and "The Combinatorics of Symmetric Functions" by J. Remmel (UC San Diego). The lectures were very much enjoyed by the participants, as well as the associated computer algebra sessions organized by N. M. Thiéry (Paris-Sud). This combination of lectures and explorations involving high-level computer algebra tools (in the open-source environment SageMath) enabled the organizers to bring up to speed rapidly newcomers to this area of research. The school lectures were recorded on video and are available through the CRM's web page.

After this first week of preparation for young researchers came the workshop. A crucial theme of the meeting was rational Catalan combinatorics and its ties with representation theory (S_n-modules of diagonal coinvariant spaces), algebraic geometry (flag bundles over the Hilbert scheme of points in the plane), colored Khovanov–Rozansky Homology of (m, n)-torus knots, and the elliptic Hall algebra. Key to these interactions was a realization of this last algebra as an algebra of operators on symmetric functions, including operators having the celebrated Macdonald polynomials as joint eigenfunctions. Many very recent and important advances regarding these ties were presented by researchers at the forefront of the developments. In fact, this was a meeting characterized by an amazing array of very interesting talks, full of surprising and elegant new results.

Undoubtedly the workshop far exceeded its aim of showing the deep convergence of some of the main questions arising in all of the subjects involved, and demonstrating that each can bring its own important contributions. Talks were given by J.-C. Aval (CNRS, LaBRI), N. Bergeron (York), J. Blasiak (Drexel), E. Carlsson (UC Davis), P. R. Di Francesco (Illinois at Urbana-Champaign), S. Fishel (Arizona State), A. M. Garsia (UC San Diego), E. Gorsky (UC Davis), J. Haglund (Pennsylvania), M. Haiman (UC Berkeley), A. Hicks (Lehigh), M. Hogancamp (Southern California), R. Kaliszewski (Lehigh), R. Kedem (Illinois at Urbana-Champaign), S. J. Lee (Seoul NU), B. Rhoades (UC San Diego), P. Samuelson (Edinburgh), A. Schilling (UC Davis), N. Williams (UC Santa Barbara), and A. Wilson (Pennsylvania).

Another noteworthy contribution came from the UQAM graduate students who prepared SageMath tutorials adapted to the workshop, a compendium of fundamental formulas, and structured notes taken during the school. Much of this material is available on the web page of the workshop (see the link "Workshop material" at the bottom of the page on the left); we plan to provide updates as new material becomes available.

Statistical Causal Inference and Its Applications to Genetics

July 25–August 19, 2016,
Université de Montréal

Sponsored by the CRM, CANSSI, PIMS, and SAMSI

Organizers: *Robin Evans (Oxford), Chris Holmes (Oxford), Marloes Maathuis (ETHZ), Erica E. M. Moodie (McGill), Ilya Shpitser (Johns Hopkins), David A. Stephens (McGill), and Caroline Uhler (MIT)*

Causal inference attempts to learn about the causal structure underlying a data generating mechanism, to understand relevant scientific processes, and to predict the effect of future interventions. This is relevant when experiments are infeasible because of impracticalities, expense, or ethical considerations. In genetics this is particularly relevant, since although experiments are sometimes possible (and becoming easier due to emerging technologies), they are often expensive, and so working with cheap observational data is extremely beneficial.

The purpose of this program was to bring together researchers in statistics and genetics to discuss the state-of-the-art of causal inference, discuss the most pressing problems relevant to it, and start solving them. The five-day workshop in week one included speakers and participants from a wide variety of career stages, geographical locations, and academic backgrounds, ranging from very applied geneticists and epidemiologists to theoretical statisticians and philosophers. To bridge the gaps, we included within each day five 60-minute "overview talks" by senior researchers to introduce a particular area: these were on constraint-based causal inference, single cell experiments, annotation methods in genetics, Mendelian randomization, and mediation analysis. Other participants were given 30-minute talks and encouraged to use the time to discuss problems to be solved rather than those that have already been overcome.

The poster session on Tuesday included excellent contributions from several students and also featured our Causal Competition, which was won by two teams from the University of Amsterdam and Radboud University (Nijmegen). They impressed the judges with their principled and practical approaches to the problem.

Many of the participants approached the organizers during the meeting to say how much they enjoyed the workshop, and reports of exciting new collaborations were abundant! A few examples include applications of SAT solvers to protein interaction networks, Mendelian randomization in cancer studies, copula models for dynamic treatment regimes, and marginal models to vaccine data.

The remainder of the program was given over to research time for a smaller group of researchers. Working and discussion groups were formed on topics including: controlling for confounding; causal inference in dynamical systems; causal networks; marginal models; and longitudinal panel data. What next? We expect this meeting to feed into a longer program at SAMSI within the next few years and hope that many of the participants will be involved again.

Past Thematic Programs

The CRM has held thematic years or semesters 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 thematic activities organized by the CRM since 1987.

April–July 2016 Computational Mathematics in Emerging Applications

June 2015–January 2016 AdS/CFT, Holography, Integrability

2014–2015 Number Theory, from Arithmetic Statistics to Zeta Elements

January–June 2014 Lie Theory

July–December 2013 Mathematics of Planet Earth 2013 — Thematic Semester on Biodiversity and Evolution

January–November 2013 Mathematics of Planet Earth 2013 — The Pan-Canadian Program on Models and Methods in Ecology, Epidemiology and Public Health

January–September 2013 Mathematics of Planet Earth 2013 — International Program in Celestial Mechanics

2012–2013 Moduli Spaces, Extremality and Global Invariants

January–June 2012 Geometric Analysis and Spectral Theory

June–December 2011 Quantum Information

January–June 2011 Statistics

July–December 2010 Geometric, Combinatorial and Computational Group Theory

January–April 2010 Number Theory as Experimental and Applied Science

August–December 2009 Mathematical Problems in Imaging Science

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

2008–2009 Probabilistic Methods in Mathematical Physics

January–June 2008 Dynamical Systems and Evolution Equations

June–December 2007 Applied Dynamical Systems

January–June 2007 Recent Advances in Combinatorics

June–December 2006 Combinatorial Optimization

2005–2006 Analysis in Number Theory

2004–2005 The Mathematics of Stochastic and Multiscale Modelling

2003–2004 Geometric and Spectral Analysis

2002–2003 Mathematics in Computer Science

2001–2002 Groups and Geometry

2000–2001 Mathematical Methods in Biology and Medicine

1999–2000 Mathematical Physics

1998–1999 Number Theory and Arithmetic Geometry

1997–1998 Statistics

1996–1997 Combinatorics and Group Theory

1995–1996 Applied and Numerical Analysis

1994–1995 Geometry and Topology

1993–1994 Dynamical Systems and Applications

1992 Probability and Stochastic Control (special semester)

1991–1992 Automorphic Forms in Number Theory

1991 Operator Algebras (thematic 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)

AISEN STADT CHAIR

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

The Aisenstadt Chair

Chairholders in 2016–2017

Nalini Anantharaman received her Ph.D. in 2000 under the supervision of François Ledrappier at the Université Pierre et Marie Curie. She worked at the ENS Lyon and at the École polytechnique before becoming a full professor at the Université Paris-Sud in 2009. She is now a Professor at the Université de Strasbourg. Professor Anantharaman held visiting positions at UC Berkeley (where she was a Visiting Miller Professor in 2009) and at IAS, Princeton in 2013.

In 2011 Nalini Anantharaman received the Jacques Herbrand Prize from the French Academy of Sciences. In 2011 she also won the Salem Prize and in 2012 she was awarded the Henri Poincaré Prize for mathematical physics. In 2013 she was awarded the *Médaille d'argent* of the CNRS. She served as Vice-President of the *Société mathématique de France*.

Nalini Anantharaman gave her lectures during the workshop on **Probabilistic Methods in Spectral Geometry and PDE** (which was part of the Thematic Semester on Probabilistic Methods in Geometry, Topology and Spectral Theory).

Scott Sheffield graduated from Harvard University in 1998 and received his Ph.D. in 2003 from Stanford University under the supervision of Amir Dembo. He held postdoctoral positions at Microsoft Research, the University of California at Berkeley, and the Institute for Advanced Study. He was an associate professor at the Courant Institute before becoming professor at the Massachusetts Institute of Technology.

Scott Sheffield received the Loève Prize, the Presidential Early Career Award for Scientists and Engineers, a Sloan Research Fellowship, and the Rollo Davidson Prize. He was also an invited speaker at the International Congress of Mathematicians in 2010.

Scott Sheffield gave his Aisenstadt lectures on September 2, 4, and 5, 2016, during the workshop on **Random Growth Problems and Random Matrices** (which was part of the Thematic Semester on Probabilistic Methods in Geometry, Topology and Spectral Theory).

Yuval Peres received his Ph.D. in 1990, from the Hebrew University, under the supervision of Hillel Furstenberg. He has contributed to the flourishing of probability theory and its connections with theoretical computer science not only through his research but also through his collaborations and training of students. He has supervised 21 doctoral students, and his influence in probability is felt both through his own work and through them.

His contributions have been recognized by his research communities in many ways: he was awarded the Rollo Davidson Prize in 1995, the Loève Prize in 2001, and the AMS David P. Robbins Prize in 2011. He gave an invited lecture at the ICM in 2002.

In 2006 Peres moved from Berkeley to the Microsoft Research Theory Group in Redmond, WA. Since then his output appears to be increasing exponentially. According to MathSciNet, 40% of his 280 publications have appeared since 2010. His fifth book, Probability on Trees and Networks, written with Russ Lyons, and sixth book, Fractals in Probability and Analysis, written with Christopher Bishop, were written in 2016. His seventh book, Game Theory, Alive, written with Anna Karlin, was published in 2017.

Peres visited the CRM in August–September 2016. During his visit, he gave three Aisenstadt Chair lectures, titled "From Laplacian growth to competitive erosion," "Competitive erosion is conformally invariant," and "Random walks on dynamical percolation."

Vic Reiner is a Distinguished McKnight University Professor at the University of Minnesota, where he began as a Dunham Jackson Assistant Professor in 1993. He obtained his Ph.D. from the MIT in 1990, working with Richard P. Stanley, who delivered the Aisenstadt Chair lectures in March 2007.

Reiner held the Aisenstadt Chair as part of the CRM thematic program on Algebra and Words in Combinatorics (March–July 2017). His research interests lie in the connections of combinatorics with fields such as

algebra, geometry, and topology. This includes several aspects of the thematic program: reflection groups; representation theory of symmetric groups; invariant theory of finite groups; computational and combinatorial commutative algebra.

He is also known for his active participation in student and postdoc training. He has advised sixteen Ph.D. students and mentored seventeen postdoctoral candidates; he has also been involved in REU programs (Research Experience for Undergraduates) since 2000.

His Aisenstadt Chair lectures, which inaugurated the thematic program, described three counting stories involving the invariant theory of reflection groups and explaining how in each case the general linear groups exhibit behaviours similar to those of reflection groups.

Boris Adamczewski is currently *Directeur de Recherche CNRS* at the Institut Camille Jordan. He obtained his Ph.D. from the Université d'Aix–Marseille II in 2002, working with Valérie Berthé. Still in an early stage of his career, his impact on current research is expanding rapidly, as acknowledged by his recently obtained ERC Consolidator Grant (among the five granted to France-based mathematicians).

Adamczewski's research interests lie in the connections between combinatorics on words, number theory, formal languages, and dynamical systems.

In addition, we mention that Adamczewski has 42 publications, which have been cited 356 times by 159 authors: one of these articles is a 50-page article published in *Inventiones Mathematicae* in 2012 and providing a characteristic *p* analogue of the Skolem–Mahler–Lech theorem in algebraic number theory for characteristic 0.

Boris Adamczewski gave Aisenstadt lectures on Automata in Number Theory on April 24, 26, 28, May 1st and 2, 2017, during the school and workshop on **Bridges between Automatic Sequences, Algebra and Number Theory** (which were part of the Thematic Semester on Algebra and Words in Combinatorics).

Previous Aisenstadt Chairholders

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, David Cox, Frans Oort, Joel S. Feldman, Roman Jackiw, Duong H. Phong, Michael S. Waterman, Arthur T. Winfree, Edward Frenkel, Laurent Lafforgue, George Lusztig, László Lovász, Endre Szemerédi, Peter Sarnak, Shing-Tung Yau, Thomas Yizhao Hou, Andrew J. Majda, Manjul Bhargava, K. Soundararajan, Terence Tao, Noga Alon, Paul Seymour, Richard Stanley, John J. Tyson, John Rinzel, Gerhard Huisken, Jean-Christophe Yoccoz, Wendelin Werner, Andrei Okounkov, Svante Janson, Craig Tracy, Stéphane Mallat, Claude Le Bris, Akshay Venkatesh, Alexander Razborov, Angus MacIntyre, Yuri Gurevich, Jamie Robins, Renato Renner, John Preskill, Richard M. Schoen, László Erdős, Elon Lindenstrauss, Fedor Bogomolov, Helmut Hofer, David Gabai, Gang Tian, Simon A. Levin, David Aldous, Martin Nowak, Masaki Kashiwara, Zeev Rudnick, Carl Pomerance, Sophie Morel, Pierre Colmez, Nikita Nekrasov, Bertrand Eynard, and Selim Esedoğlu.

SUMMER SCHOOLS

Each year the CRM sponsors the *Séminaire de mathématiques supérieures* or SMS (a summer school that is the oldest continuous mathematical activity in Montréal).
This year the topic of the SMS was Dynamics of Biological Systems and it was held at the University of Alberta.
The CRM organized two other summer schools, respectively on Spectral Theory and Applications (at the Université Laval) and on Deep Learning (at the CRM).

Summer Schools

SMS 2016 Summer School Dynamics of Biological Systems

May 29–June 11, 2016,
University of Alberta

Sponsored by the following institutions: PIMS, CRM, Fields Institute, ISM, MSRI, University of Alberta, CMS, and Springer

Organizers: *Mark Lewis (Alberta), Thomas Hillen (Alberta), and Yingfei Yi (Alberta)*

Here are the names and affiliations of the instructors and the course titles.

Benoît Perthame (Pierre et Marie Curie)

Bacterial Motion, Motivation and Analysis Micro-Macro, Travelling Pulses, Internal States, Fast Reaction — Stiff Response

Philip Maini (Oxford)

Pattern Formation, Turing Model, Chemotaxis Model, Linear Stability Analysis, Applications

Travelling Waves, Description of the Fisher Equation and Analysis for Minimum Wavespeed, Applications

Applications of Hybrid Models for Cell Motion

Gerda de Vries (Alberta)

The Cell Membrane and the Hodgkin–Huxley Model

Numerical Exploration and Qualitative Analysis

Models for Bursting Electrical Activities

Hong Qian (Washington)

Complex Biological Dynamics: A Chemical Reaction Kinetic Perspective. I, II, and III

Réka Albert (Penn State)

The Structure of Molecular Networks

Logic Modeling of the Dynamics of Molecular Networks

Connecting the Structure and Dynamics of Molecular Networks

Zhilan Feng (Purdue)

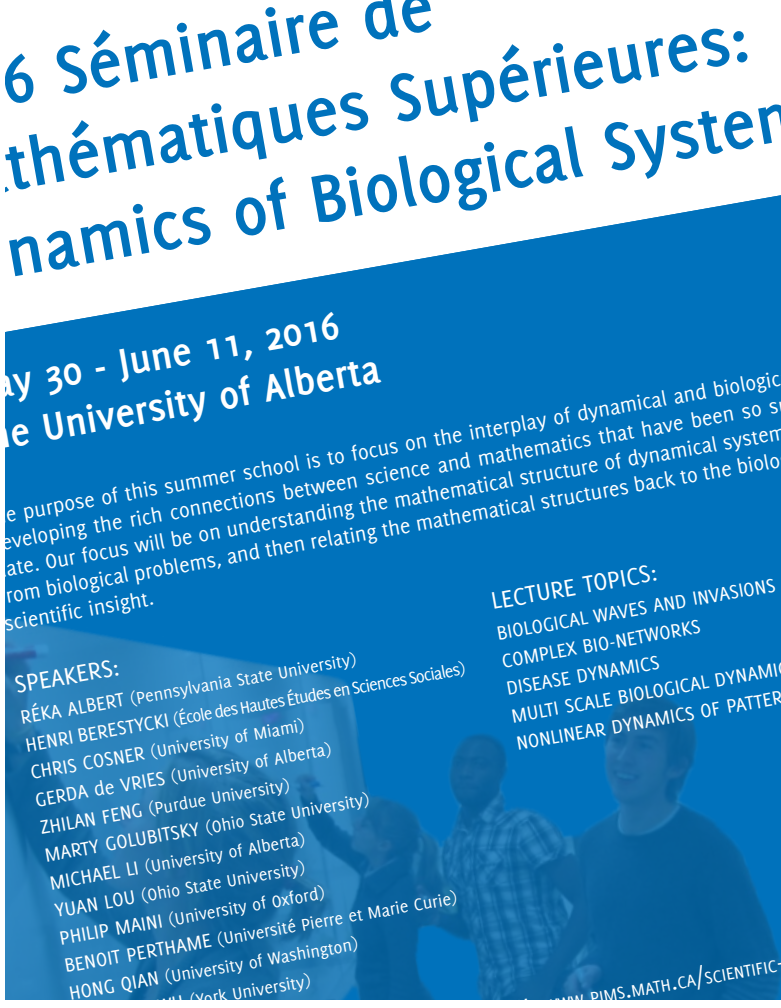
An Elaboration of Theory about Preventing Outbreaks in Homogeneous Populations to Include Heterogeneity or Preferential Mixing

Emerging Disease Dynamics in a Model Coupling Within-Host and Between-Host

Systems Hopf and Homoclinic Bifurcations and Applications in Epidemiological Models

Michael Li (Alberta)

Large Scale Epidemic Models and a Graph-Theoretic Method for Constructing Lyapunov Functions. I, II, and III



Chris Cosner (Miami)

Models for a Single Population

Interacting Populations in Ecology

Interacting Populations in Evolution

Martin Golubitsky (Ohio State)

Networks, Symmetries and Applications. I, II, and III

Jianhong Wu (York)

Spatiotemporal Patterns of Bird Migration and Seasonal Stage-Activities of Tick Populations: Model Formulation and Parametrization

Global Dynamics

Avian Influenza Spread and Lyme Disease Epidemics

Yuan Lou (Ohio State)

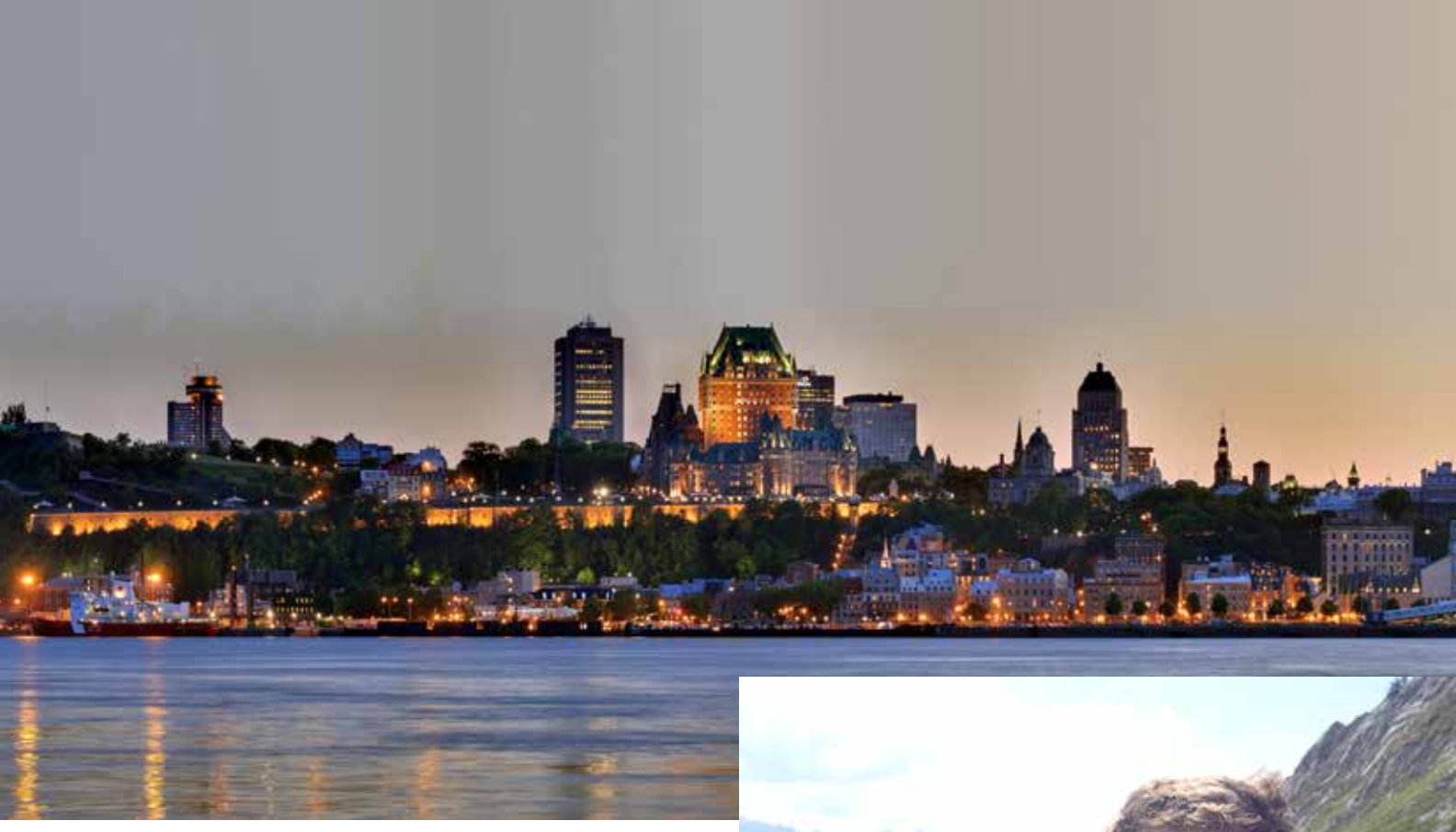
An Introduction to the Logistic Model

Diffusion Driven Extinction in Heterogeneous Environment

Persistence and Competition in Rivers

Henri Berestycki (EHESS)

Reaction-Diffusion and Propagation in Non-Homogeneous Media. I, II, and III



2016 CRM Summer School
Spectral Theory and Applications

July 4–14, 2016, Université Laval

Sponsored by the CRM, GIREF, the ISM, and the NSF

Organizers: *Catherine Bénéteau (South Florida), Alexandre Girouard (Laval), Dmitry Khavinson (South Florida), Javad Mashreghi (Laval), Thomas J. Ransford (Laval)*

Here are the names and affiliations of the instructors and the course titles

Ram Band (Technion)

Spectral Graph Theory

Yaiza Canzani (Harvard)

Spectral Geometry

Richard Froese (UBC)

Quantum Mechanics

Felix Kwok (Hong Kong)

Numerical Methods

Richard Laugesen (Illinois–Urbana-Champaign)

Spectrum of Elliptic Operators

Thomas Ransford (Laval)

Fundamental Spectral Theory

Deep Learning Summer School 2016

August 1–7, 2016, CRM

Sponsored by the CRM and CIFAR

Organizers: *Aaron Courville (Montréal), Yoshua Bengio (Montréal)*

Here are the names and affiliations of the instructors and the course titles.

Doina Precup (McGill)

Machine Learning

Hugo Larochelle (Twitter & Sherbrooke)

Neural Networks I, II

Pascal Lamblin (Montréal)

Introduction to Theano

Rob Fergus (Courant Institute, NYU)

Convolutional Neural Networks and Computer Vision

Antonio Torralba (MIT)

Learning to See

Alex Wiltschko (Twitter)

Introduction to Torch

Yoshua Bengio (Montréal)

Recurrent Neural Networks

Sumit Chopra (Facebook)

Reasoning, Attention and Memory

Jeff Dean (Google)

Large Scale Deep Learning with TensorFlow

Kyunghyun Cho (Courant Institute, NYU)

Deep Natural Language Understanding

Edward Grefenstette (DeepMind)

Beyond Seq2Seq with Augmented RNNs

Julie Bernauer (NVIDIA)

GPU programming for Deep Learning

Joëlle Pineau (McGill)

Introduction to Reinforcement Learning

Pieter Abbeel (UC Berkeley)

Deep Reinforcement Learning

Ruslan Salakhutdinov (Carnegie Mellon)

Deep Generative Models I

Shakir Mohamed (DeepMind)

Building Machines that Imagine and Reason: Principles and Applications of Deep Generative Models

Bruno Olshausen (UC Berkeley)

Beyond Inspiration: Five Lessons from Biology on Building Intelligent Machines

Surya Ganguli (Stanford)

Theoretical Neuroscience and Deep Learning Theory

OTHER ACTIVITIES

The CRM organizes and sponsors several other activities in various areas of mathematics. Some of these belong to the general program for activities held at or outside the CRM or organized by other institutions.

"Other activities" also include the activities of the interdisciplinary and industrial program and those organized by the laboratories. In 2016–2017, seven workshops were held at the CRM as part of the general program and ten were held elsewhere. The CRM held three workshops within the interdisciplinary and industrial program. As for the laboratories, they organized nine workshops.

Finally, the CRM, in collaboration with the *Institut des sciences mathématiques* (ISM), organizes the *Colloque des sciences mathématiques du Québec*, a series of survey lectures given by mathematicians and statisticians of international renown on topics of current interest.

Other Activities

General Program

The general program is used to finance a variety of scientific events, from highly specialized workshops for a small number of researchers to congresses for hundreds of participants. The general program aims to encourage the development of research in the mathematical sciences at all levels. The program is flexible and projects are reviewed as they are proposed..

Activities Held at the CRM

Workshop
Algebraic Cycles and Modules
June 2–8, 2016, Université de Montréal

Sponsored by the NSF and the Foundation Compositio Mathematica

Organizers: *Patrick Brosnan (Maryland), Matt Kerr (Washington University in St. Louis), Matilde Lalín (Montréal), Radu Laza (Stony Brook), James D. Lewis (Alberta), Gregory Pearlstein (Texas A&M), Colleen Robles (Duke)*

44th Canadian Annual Symposium on Operator Algebras and Their Applications (COSy)
June 13–17, 2016, Université de Montréal

Organizers: *George A. Elliott (Toronto), Mikaël Pichot (McGill)*

School
Abecedarian of SIDE (ASIDE)
June 27–July 1st, 2016, Université de Montréal

Sponsored by the CRM, the UMI CRM, and the NSF

Organizers: *Ferenc Balogh (John Abbott College), Decio Levi (Roma Tre), Raphaël Verge-Rebelo (Collège Ahuntsic), Bart Vlaar (Nottingham), Pavel Winternitz (Montréal)*

Entanglement
and Quantumness Workshop
August 22–23, 2016, CRM

Organizers: *Gilles Brassard (Montréal), Tal Mor (Technion)*

13th Workshop on Algorithms and Models for the Web-Graph
December 14–15, 2016, CRM

Sponsored by the CRM, Google, Yandex, Ryerson University, and Lecture Notes in Computer Science

Steering Committee: *Andrei Z. Broder (Google), Fan Chung Graham (UC San Diego)*

Co-Chairs and Co-Organizers: *Anthony Bonato (Ryerson), Fan Chung Graham (UC San Diego), Pawel Pralat (Ryerson)*

24 heures de science (12e édition)
Mathématiques et fiction
May 12, 2017, Université de Montréal

Sponsored by the CRM, CIRRELT, GERAD, the ncm$_2$, CIRANO, and the ISM

Organizer: *Christiane Rousseau (Montréal)*

Journée des sciences des données en santé
May 16, 2017, Université de Montréal

Sponsored by the CRM and the Faculty of Graduate and Postdoctoral Studies of the Université de Montréal

Organizer: *Jean-François Angers (Montréal)*

Activities Held Outside of the CRM

Theory Canada 11 Conference
June 9–11, 2016, Carleton University

Sponsored by CITA, the Perimeter Institute, the Faculty of Sciences of Carleton University, the CRM, and the Fields Institute

Organizers: *Thomas Grégoire (Carleton), Steve Godfrey (Carleton), Heather Logan (Carleton), Daniel Stolarski (Carleton), Svetlana Barkanova (Acadia), Ariel Edery (Bishop's)*

12th International Conference on Symmetries and Integrability of Difference Equations (SIDE12)
July 3–9, 2016, Hôtel Chanteclerc, Sainte-Adèle

Sponsored by the CRM, the UMI CRM, and the NSF

Scientific Committee: *Alexander Bobenko (TU Berlin), Basile Grammaticos (CNRS, IMNC), Jarmo Hietarinta (Turku), Nalini Joshi (Sydney), Kenji Kajiwara (Kyushu), Decio Levi (Roma Tre), Frank W. Nijhoff (Leeds), Vassilios Papageorgiou (Patras), Junkichi Satsuma (Aoyama Gakuin), Yuri B. Suris (TU Berlin), Claude Viallet (CNRS , LPTHE), Pavel Winternitz (Montréal), Da-jun Zhang (Shanghai)*

Organizers: *Decio Levi (Roma Tre), Pavel Winternitz (Montréal), Véronique Hussin (Montréal), Mourad E. H. Ismail (Central Florida), Raphaël Verge-Rebelo (Collège Ahuntsic), Zora Thomova (SUNY Poly)*

Conference on Differential Geometry

July 5–9, 2016, UQAM

Sponsored by CIRGET, the UMI CRM, and the NSF

Organizers: *Vestislav Apostolov (UQAM), Olivier Biquard (ÉNS), Xiuxiong Chen (Stony Brook & USTC), Akito Futaki (Tokyo), Massimiliano Pontecorvo (Roma Tre)*

Workshop Numerical Analysis of Singularly Perturbed Differential Equations

July 25–29, 2016, Saint Mary's University

Sponsored by AARMS, the CRM, the NSF, Memorial University, Saint Mary's University

Organizers: *Hermann Brunner (Memorial), Ronald Haynes (Memorial), David Iron (Dalhousie), Theodore Kolokolnikov (Dalhousie), Scott MacLachlan (Memorial), Paul Muir (Saint Mary's)*

Two Weeks in Vancouver – A Summer School for Women in Math

August 15–25, 2016, UBC

Sponsored by PIMS, the Fields Institute, UBC, the CRM, and Goldcorp

Organizers: *Shawn Desaulniers (UBC), Rachel Kuske (UBC), Fok-Shuen Leung (UBC), Malabika Pramanik (UBC)*

14th RECOMB Comparative Genomics Satellite Workshop

October 11–14, 2016, Hôtel de l'Institut de tourisme et d'hôtellerie du Québec

Sponsored by the CRM, Université de Montréal, the CHU Sainte-Justine, UQAM, and PIMS

Steering Committee: *Jens Lagergren (Stockholm), Aoife McLysaght (Dublin), David Sankoff (Ottawa)*

Organizing Committee: *Cédric Chauve (Simon Fraser), Nadia El-Mabrouk (Montréal), Abdoulaye Baniré Diallo (UQAM), Benzaid Billel (Montréal), Luis Barreiro (Montréal), Gertraud Burger (Montréal), Sylvie Hamel (Montréal), Manuel Lafond (Montréal), Franz Lang (Montréal), Robin Milosz (Montréal), Emmanuel Noutahi (Montréal)*

60e Congrès de l'AMQ Des mathématiques surprenantes

October 14–15, 2016, Cégep Garneau

12th International Conference on Web and Internet Economics (WINE)

December 11–14, 2016, InterContinental Hotel, Montréal

Sponsored by the CRM, Facebook, Google, Microsoft Research, Springer, and GERAD

General and Program Chairs: *Yang Cai (McGill), Adrian Vetta (McGill)*

Poster Chair: *Vasilis Gkatzelis (Drexel)*

Steering Committee: *Xiaotie Deng (Shanghai Jiao Tong), Ehud Kalai (Microsoft & Northwestern), Christos Papadimitriou (UC Berkeley), Paul Spirakis (Liverpool & Patras), Yinyu Ye (Stanford)*

SUMM 2017 – Seminars in Undergraduate Mathematics in Montreal

January 13–15, 2017, McGill University

Sponsored by the CRM, the ISM, the CMS, and four Montreal universities (Concordia, McGill, Université de Montréal, and UQAM, including the mathematics departments and student associations of these universities)

Organizers: *Emilia Alvarez (Concordia), Gabriel Boisvert-Beaudry (Montréal), Raphaëlle Élément (Montréal), Antoine Giard (Montréal), Asher Klein (Concordia), Alexis Langlois-Rémillard (Montréal), Rox-Anne L'Italien-Bruneau (UQAM), Lycia Mameri (UQAM), David Marcil (McGill), Véronique Marcotte (UQAM), Émile Nadeau (UQAM), Nicola-Amanda Perry (Concordia), Renaud Raquépas (McGill), Stéphanie Schanck (UQAM), Ben Sigman (Montréal)*

Theory Canada 12 Conference

May 25–27, 2017, York University

Sponsored by the Fields Institute, York University, the Perimeter Institute, CITA, the CRM, the Institute of Particle Physics, NSERC, and the Government of Ontario

Organizers: *Svetlana Barkanova (Memorial), Ariel Edery (Bishop's), Marko Horbatsch (York), Matthew Johnson (Perimeter), Tom Kirchner (York), Ray Lewis (York)*

Interdisciplinary and Industrial Program

The CRM has been organizing industrial problem solving workshops since 2007. In 2014 the three Canadian mathematics institutes (the CRM, the Fields Institute, and PIMS) were awarded an NSERC grant, called the Institutes Innovation Platform, to develop their industrial collaborations. This grant enabled the CRM to hire a Partnerships Development Officer, Dr. Stéphane Rouillon, and to organize more problem solving workshops. The CRM also decided to hold another kind of workshops, called networking industrial workshops. Such a workshop lasts for one day and consists of presentations by industrial partners, presentations by CRM laboratories, and exchanges between academic researchers and representatives from industry. Here are the workshops that took place in 2016–2017.

CRM Networking Industrial Workshop Energy

October 24, 2016, CRM

CRM Networking Industrial Workshop Data Analysis, Modelling, and Decision-Making Support

January 27, 2017, Université Laval

Sponsored by NSERC and Université Laval

CRM Networking Industrial Workshop Advanced Materials

May 15, 2017, Université de Montréal

Activities Organized by the Laboratories

The members of the CRM laboratories organize not only activities within the thematic, general, and interdisciplinary CRM programs, but also activities that are supported by the laboratories themselves. In particular the Mathematical Analysis Laboratory created the CRM Nirenberg Lectures, named in honour of the famous mathematician Louis Nirenberg, who has strong connections with Montréal. Here are the activities organized by the laboratories in 2016–2017.

Summer Meeting of the Statistics Laboratory

June 17, 2016, Université de Montréal

Sponsored by the Statistics Laboratory

Organizer: *Éric Marchand (Sherbrooke)*

New Trends in Approximation Theory

July 25–29, 2016, Fields Institute

Sponsored by the Mathematical Analysis Laboratory, the Fields Institute, NSERC, and the Government of Ontario

Organizers: *Paul Gauthier (Montréal), Myrto Manolaki (UC Dublin), Javad Mashreghi (Laval)*

STAHY 2016 Workshop

September 26–27, 2016, INRS

Sponsored by the INRS, CANSSI, the Statistics Laboratory, WSP, Desjardins Insurance, the IAHS, the FRQNT, and the SSC

2016 Québec–Maine Number Theory Conference

October 9–10, 2016, Université Laval

Sponsored by CICMA, the NTF, the NSF, the CRM, and the Department of Mathematics and Statistics of the Université Laval

Organizers: *Hugo Chapdelaine (Laval), Jean-Marie De Koninck (Laval), Antonio Lei (Laval), Claude Levesque (Laval)*

2016 Montreal–Toronto Workshop in Number Theory

December 8–9, 2016, CRM

Sponsored by CICMA

Organizers: *Henri Darmon (McGill), Stephen Kudla (Toronto)*

6TH GRADUATE STUDENT WORKSHOP IN INSURANCE AND FINANCIAL MATHEMATICS

March 17, 2017, UQAM

Sponsored by Quantact

Organizers: *Geneviève Gauthier (HEC Montréal), Ghislain Léveillé (Laval), Anne MacKay (UQAM), Mélina Mailhot (Concordia), Manuel Morales (Montréal)*

NON-LIFE INSURANCE WORKSHOP

March 24, 2017, Concordia University

Sponsored by Quantact

Organizers: *Mathieu Pigeon (UQAM), Mélina Mailhot (Concordia)*

CRM NIRENBERG LECTURES IN GEOMETRIC ANALYSIS THE ONSAGER'S THEOREM

Camillo De Lellis (Zürich)
March 24, 27, and 28, 2017, CRM

Sponsored by the Mathematical Analysis Laboratory

Organizers: *Iosif Polterovich (Montréal), Alina Stancu (Concordia), Dmitry Jakobson (McGill), Pengfei Guan (McGill)*

SPRING MEETING OF STATLAB

May 17, 2017, Université Laval

Sponsored by the Statistics Laboratory and the ASSQ

Organizers: *Éric Marchand (Sherbrooke), Louis-Paul Rivest (Laval)*

COLLOQUE DES SCIENCES MATHÉMATIQUES DU QUÉBEC

In 2016–2017 the colloquium was under the responsibility of: Olivier Collin (UQAM), Henri Darmon (McGill), Dimitri Koukoulopoulos (Montréal), Iosif Polterovich (Montréal), David A. Stephens (McGill), Hugh Thomas (UQAM), and Yang Yi (McGill) for Montréal; and Ting-Hue Chen and Louis-Paul Rivest (both from Université Laval) for Québec City.

SEPTEMBER 16, 2016, UQAM

Nick Trefethen (University of Oxford)

Cubature, Approximation, and Isotropy in the Hypercube

SEPTEMBER 16, 2016, CONCORDIA UNIVERSITY

B. L. S. Prakasa Rao (CR Rao Advanced Institute)

Statistical Inference for Fractional Diffusion Processes

SEPTEMBER 30, 2016, UQAM

Liam Watson (Université de Sherbrooke)

Notions of Simplicity in Low Dimensions

OCTOBER 14, 2016, UNIVERSITÉ DE MONTRÉAL

Jean-Philippe Lessard (Université Laval)

Rigorously Verified Computing for Infinite Dimensional Nonlinear Dynamics: A Functional Analytic Approach

OCTOBER 21, 2016, UNIVERSITÉ DE MONTRÉAL

Ivan Corwin (Columbia University)

Integrable Probability and the KPZ Universality Class

OCTOBER 28, 2016, MCGILL UNIVERSITY

Jerry Lawless (University of Waterloo)

Efficient Tests of Covariate Effects in Two-Phase Failure Time Studies

November 4, 2016, Université de Montréal

Philippe G. Le Floch
(CNRS, Laboratoire Jacques-Louis Lions)

The Nonlinear Stability of Minkowski Space for Self-Gravitating Massive Fields

November 25, 2016, UQAM

Maksym Radziwiłł (McGill University)

Around the Möbius Function

December 1st, 2016, McGill University

Richard Samworth (University of Cambridge)

High-Dimensional Changepoint Estimation via Sparse Projection

December 2, 2016, UQAM

GuiQiang G. Chen (University of Oxford)

Partial Differential Equations of Mixed Elliptic–Hyperbolic Type in Mechanics and Geometry

January 20, 2017, UQAM

Christopher Skinner (Princeton University)

The Birch-Swinnerton Dyer Conjecture and Counting Elliptic Curves of ranks 0 and 1

February 10, 2017, UQAM

Mark Powell (UQAM)

Knot Concordance

February 24, 2017, Université de Montréal

Frithjof Lutscher (University of Ottawa)

Spreading Phenomena in Integrodifference Equations with Overcompensatory Growth Function

March 10, 2017, Université de Montréal

Louigi Addario-Berry (McGill University)

Probabilistic Aspects of Minimum Spanning Trees

March 17, 2017, McGill University

Sayan Mukherjee (Duke University)

Inference in Dynamical Systems

March 3, 2017, UQAM

Tatiana Toro (University of Washington)

PDEs on NonSmooth Domains

April 6, 2017, Université Laval

Jason Fine
(University of North Carolina at Chapel Hill)

Instrumental Variable Regression with Survival Outcomes

April 7, 2017, UQAM

Gabor Szekelyhidi (University of Notre Dame)

Kähler–Einstein Metrics

April 21, 2017, UQAM

Aaron Naber (Northwestern University)

Introduction to the Energy Identity for Yang–Mills

May 5, 2017, UQAM

Gerard Freixas Montplet
(CRNS et Institut de mathématiques de Jussieu, Paris Rive Gauche)

From the Geometry of Numbers to Arakelov Geometry

GRANDES CONFÉRENCES

In 2006 the CRM launched the “Grandes Conférences” lecture series in order to fulfill the expectations of a public wishing to understand important developments in the mathematical sciences. The “Grandes Conférences du CRM” feature outstanding lecturers whose presentations convey the power and beauty of mathematical research to a wide audience.

“Grandes Conférences du CRM”

Two lectures were delivered at the Université de Montréal in 2016–2017: “Les maths de l’intelligence... artificielle” (The Mathematics of Artificial Intelligence) by Alain Tapp (on November 22, 2016); and “Paul Lévy et les cygnes noirs” (Paul Lévy and Black Swans) by Gérard Ben Arous (on March 16, 2017). The reader will find below summaries inspired in part by texts published in Le Bulletin du CRM by Christiane Rousseau and Alexander Fribergh, respectively.

Each of the lectures was attended by hundreds of participants of various ages. Receptions held after the lectures allowed members of the audience to ask questions, renew old acquaintances, and meet other attendees interested in science. The “Grandes Conférences” program is under the stewardship of Christiane Rousseau and Yvan Saint-Aubin, both full professors in the Department of Mathematics and Statistics at the Université de Montréal.

“Les maths de l’intelligence... artificielle”

Alain Tapp (Université de Montréal)

On November 22, 2016, a large audience came to the Université de Montréal to attend a lecture by Alain Tapp on his new passion, artificial intelligence. In 1996 IBM Deep Blue won a chess match against Garry Kasparov. The computers have amazed us ever since. Where will they stop?

The eye–brain tandem in humans is an extraordinary one. When presented with a picture featuring a dog, a human will recognize that it is a dog, even if the shapes, breeds, colours, and positions of dogs are extraordinarily diverse. A human can also sort pictures to recognize those containing snow and dogs. Computers are now able to do this kind of sorting. They can select pictures featuring sunsets or cemeteries. Machine translation has greatly improved and is still improving. Autonomous vehicles will soon outperform human drivers.

In 2015, Stephen Hawking, Elon Musk, and tens of experts in artificial intelligence signed an open letter, stating (among other things): “There is now a broad consensus that AI research is progressing steadily... We recommend expanded research aimed at ensuring that increasingly capable AI systems are robust and beneficial: our AI systems must do what we want them to do.”

Human beings can learn by trial and error without being told everything explicitly. A great shift occurred in the area of artificial intelligence when one started to program machines so that they would “learn” on their own. Machines are better than us at mining data and looking for information.

Professor Tapp centered his lecture on a particular task: the deciphering of hand-written digits. He described how various methods (ever more sophisticated) are used to perform this task. One such method consists of sorting digits by analyzing the pixels in their scanned images. A digit is thus represented by a matrix whose elements are shades of gray. What are the commonalities between matrices representing the same digit? One can introduce a distance between those matrices, considered as vectors in the 784-dimensional Euclidean space. When a new digit has to be deciphered, one decides what the picture represents by minimizing the distance between the corresponding matrix and the matrices corresponding to known digits. The method just described has an error rate of 3.8 percent.

A more sophisticated method looks at multidimensional data. Looking at a single variable may make it difficult to account for some aberrations in the values of this variable. On the other hand linear laws may be discovered when *n*-uples of variables are considered: the higher the dimension, the lower the rate of aberrant values. Not all laws, however, are linear, and some aspects of data sets can be explained by nonlinear laws. In the instance of digit recognition, a hyperplane with a quadratic kernel allows one to decrease the error rate to 1.9 percent.

Professor Tapp then addressed his central issue by comparing the human brain (whose characteristics are power, capacity, brute force) with FLOPS or floating point operations per second, from the Intel processor with 90 giga-FLOPS to the Tianhe-2 supercomputer with 90 peta-FLOPS (1 peta-FLOPS = 1015 FLOPS). The human brain, with 86 billion neurones, has a power of one exa-FLOPS (1 exa-FLOPS = 1018 FLOPS). Can the brain be a model for artificial intelligence? It consists of several layers of neurones. When presented with a digit (for instance the digit 2), one area of the brain is activated while the other areas are not. In some artificial intelligence algorithms, the inputs of artificial neurones are vectors and these neurones must compute some output. The underlying idea is to build neurone layers and to make them learn.

To do this, Geoffrey Hinton introduced backpropagation (an algorithm for computing gradients). Roughly speaking, the input and the desired output are compared by evaluating an error function. One then determines in what direction the neurones must be modified in order to “improve” the error function, which amounts to determining the gradient of the error function. Applying this method gives good results for recognizing digits and spectacular ones for recognizing images! In the instance of digit recognition, supervised learning is used, but one can do much better by using large-scale learning in deep networks.

Google started using this methodology in 2013, in order to classify images found anywhere on the web, including YouTube videos. The neurone network developed by Google learned on its own to recognize faces, cats, many animals or objects, and so on. This network had 9 layers and 1 giga connections. The training of the network was carried out on 1000 machines and required 72 hours per analysis of ten million YouTube images. Nowadays deep networks are trained directly and their performance is impressive: the results of the annual LSVR (Large-Scale Visual Recognition) contest testify to this, since it features systems able to classify 1000 categories (including 120 dog breeds).

The same method, applied to digit recognition, has an error rate of 0.3 percent, which is comparable to the error rate of a human being.

The audience was fascinated by the lecture. What will artificial intelligence be able to do? Many things, in Professor Tapp’s opinion... And Montreal is on the map!

"Paul Lévy et les cygnes noirs"

Gérard Ben Arous (Courant Institute, NYU)

In his lecture on March 16, 2017, Gérard Ben Arous wished to present the life and work of Paul Lévy, a French mathematician who studied a concept called "heavy tail distribution." This concept turned out to be crucial in the study of so-called "black swans," i.e., very rare events with drastic consequences for the world (such as financial crises or pandemics).

In the first part of his lecture, Gérard Ben Arous surveyed the history of probability theory. For a long time, probabilities were not deemed to be a topic that could be investigated with rigour. Preliminary results tended to show that chance was not an important phenomenon in everyday life. Ben Arous began by presenting two central results in probability theory.

1. The law of great numbers, stating that the empirical mean of an experiment (repeated a large number of times) converges to the mean result of a single experiment. For instance, if one plays heads or tails (winning 1 dollar for a "head" and losing 1 dollar for a "tail"), and if one denotes by S_N the wealth after N iterations, then S_N/N will converge to 0.
2. The Central Limit Theorem, stating that the typical deviations with respect to the mean result are small and follow the model of the Gaussian distribution. In the case of heads or tails, the deviations are of the order of the square root of N and S_N divided by the square root of N follows the Gaussian distribution asymptotically.

Both results imply that the real world is stable and predictable, but this is not necessarily what we observe.

Now we must consider Paul Lévy's work. At the beginning of the twentieth century, he was a brilliant young mathematician who became a professor at the École polytechnique. His interest for probability theory arose when somebody asked him to give a series of talks on this topic within his courses. His interest and the recent attempts by Kolmogorov to formalize probability theory led to rapid advances in the field. Among the many works of Paul Lévy, Gérard Ben Arous chose to focus on heavy-tailed random variables. This concept is used in modelling a random experiment having a minuscule probability of occurring and having a major impact, indeed an impact as important as the combined impact of all the preceding events.

To give a concrete example of such a random variable, Gérard Ben Arous chose to compare a "sample of weights" and a "sample of personal wealths." Consider a sample of 1000 New York men aged between 50 and 60. Their average weight is between 80 and 90 kilos, for a total weight of 85,000 kilos. It would be unreasonable to think that any person within that group represents a significant fraction of the total weight, since the largest individual weight is probably around 200 kilos. On the other hand, if one assumes that the average wealth of one of these men is around $100,000, then the total wealth is around 100 million dollars. It is reasonable to imagine that the richest man in our sample owns a sizeable fraction (say, 5 million dollars) of the total wealth. This example illustrates the difference between light-tailed distributions (e.g., the weight distribution) and heavy-tailed distributions (e.g., the wealth distribution).

Paul Lévy has studied and understood the behaviour of heavy-tailed random variables. They follow a stable distribution, not a Gaussian one. He also discovered a new stochastic process (now called "Lévy flight"), which corresponds to Brownian motion (the typical motion of a random object) but in the context of heavy-tailed random variables. Gérard Ben Arous gave a long list of recent examples where scientists have observed Lévy flights while studying certain phenomena: the moving patterns of an ancient tribe of hunters-gatherers, the movement of certain proteins in the brain, and the hunting patterns of sharks. Lévy flights also play a very important role in mathematics and finance, especially since the financial crisis of 2008–2009.

The lecture of Ben Arous on Paul Lévy's life introduced his audience (in a concrete and playful manner) to some fundamental results in probability theory, as well as the "philosophy" undelying this branch of mathematics.

LABORATORIES

The CRM laboratories act as focal points for local research in mathematics and participate actively in the scientific programming of the CRM. Members of the laboratories organize thematic years or semesters, coordinate activities and seminars sponsored by the laboratories themselves, and train graduate students and postdoctoral fellows. The laboratories involve members from many universities and thus greatly facilitate collaboration between researchers in Québec.

Laboratories

Mathematical Analysis

At the same time classical and central to modern mathematics, analysis involves the study of continuous systems, from dynamical systems to solutions of partial differential equations and spectra of operators. The laboratory includes regular and associate members working at more than ten different universities in Canada, the United Kingdom, France, and Austria. The members of the laboratory work in the following areas: harmonic analysis, complex analysis, several complex variables, potential theory, functional analysis, Banach algebras, microlocal analysis, analysis on manifolds, non-smooth analysis, spectral theory, partial differential equations, geometric analysis, ergodic theory and dynamical systems, control theory, mathematical physics, probability, non-linear analysis, non-linear differential equations, topological methods in differential equations, fluid dynamics, and turbulence.

The laboratory members organize (on their own or with other laboratories) several seminars that take place regularly in Montréal universities, at the Université Laval, and at the Université de Sherbrooke.

Highlights

In 2016–2017 Damir Kinzebulatov joined the Department of Mathematics and Statistics at the Université Laval and was elected a regular member of the Analysis Laboratory. Kinzebulatov received his Ph.D. from the University of Toronto in 2012 under the direction of P. Milman. He has won the Malcolm Slingsby Robertson Prize in Mathematics for his thesis. He was an NSERC postdoc at the Fields Institute from 2012 to 2014, a postdoctoral fellow at McGill in 2015, and a visiting assistant professor at Indiana University in 2016. Kinzebulatov is an analyst who applies methods from harmonic analysis and operator theory to problems in complex analysis and PDEs. His current interests include diffusion with drifts, Anderson localization, and Oka-Cartan theory.

From August to December 2016, Analysis Laboratory members organized, with members of the Probability Laboratory, a thematic semester on Probabilistic Methods in Geometry, Topology and Spectral Theory. This semester is described in the section of the present report on the CRM thematic programs. Professor Camillo De Lellis, from the University of Zürich, gave three lectures within the framework of the Nirenberg Lectures in Geometric Analysis (the most prestigious event organized by the Analysis Laboratory). He discussed Onsager's theorem, his work on Onsager's conjecture, and connections to the isometric embedding theorem of Nash and the h-principle of Gromov.

Students and Postdoctoral Fellows

In 2016–2017, the members of the Mathematical Analysis Laboratory supervised 27 M.Sc. students, 27 Ph.D. students, and 12 postdoctoral fellows.

Director

Dmitry Jakobson (McGill)

Regular Members

Marlène Frigon, Paul M. Gauthier, Iosif Polterovich, Christiane Rousseau, Dana Schlomiuk (Montréal)

Stephen W. Drury, Vojkan Jakšić, Paul Koosis, John A. Toth, Jérôme Vétois (McGill)

Abraham Boyarsky, Galia Dafni, Pawel Góra, Alexey Kokotov, Alexander Shnirelman, Alina Stancu, Ron J. Stern (Concordia)

Line Baribeau, Alexandre Girouard, Frédéric Gourdeau, Javad Mashreghi, Thomas J. Ransford, Jérémie Rostand (Laval)

Tomasz Kaczinski (Sherbrooke)

Dominic Rochon (UQTR)

Vadim Kaimanovich (Ottawa)

Richard Fournier (Dawson College)

Francis H. Clarke (Université Claude Bernard)

Robert Seiringer (IST Austria)

Associate Members

Octav Cornea, Richard Duncan, Samuel Zaidman (Montréal)

Kohur Gowrisankaran, Pengfei Guan, Niky Kamran, Ivo Klemes (McGill)

John Harnad, Dmitry Korotkin (Concordia)

Nilima Nigam (Simon Fraser)

Yiannis Petridis (University College London)

CAMBAM
Centre for Applied Mathematics in Bioscience and Medicine

The mission of CAMBAM is to be a leading institution in the application of mathematics to address challenges in bioscience and medicine through partnerships with industry, government, and other stakeholders in society. CAMBAM meets its objectives by promoting and fostering research, teaching, and training in applications of quantitative biology at all levels, ranging from the molecular/genetic through single-cell and whole-organ physiology and biology to population dynamics and broader ecological questions, on time scales from the present to the evolutionary; by honing the talents of students at all levels through unique training opportunities in academic and non-academic settings; and by conducting applied research of the highest scientific rigour, meeting existing industry and societal demands in clinical and public health settings.

CAMBAM organizes two seminar series. The first series, called Cutting Edge Lecture Series, is geared towards the general public and consists of one lecture per month, delivered at the Redpath Museum of McGill University. Each lecture draws more than 80 persons. The second series is attended by CAMBAM members: it consists of lectures delivered by CAMBAM researchers and invited researchers, who present their work.

Highlights

During the 2016–2017 academic year, CAMBAM organized a series of successful lectures at McGill University in biology and mathematics (26 lectures overall). This series was a good opportunity to gather prestigious lecturers from abroad, such as Leah Keshet (UBC), Mitchell Feigenbaum (Rockefeller), Farzan Nadim (New Jersey Institute of Technology), Marc Ryser (Duke), Frithjof Lütscher (Ottawa), John Rinzel (NYU), and Alan Perelson (Los Alamos National Laboratory). CAMBAM also offered eight scholarships to student members of CAMBAM (for a total amount of $40,000). The annual CAMBAM event took place on May 31st at McGill University and 46 participants attended for a total of 19 oral presentations given by student members of the laboratory.

Once again, CAMBAM organized a summer school with the MBI (Mathematical Biosciences Institute, Ohio State University) and the NIMBioS (National Institute for Mathematical and Biological Synthesis). In 2016, the summer school took place at the MBI on the theme of infectious diseases modelling. In 2017, the summer school was organized at the NIMBioS on the theme of the integration of predictive models. CAMBAM was also involved in the organization of the workshop on quantitative therapeutic approaches led by Fahima Nekka at the Université de Montréal in June of 2017.

In 2016–2017, members of CAMBAM continued to shine in the scientific world by publishing articles in prestigious journals. We mention in particular the articles “Demonstration of cardiac rotor and source mapping techniques in embryonic chick monolayers” (published in *Chaos* with Leon Glass as a co-author), “Predicting the spread of all invasive forest pests in the United States” (published in *Ecology Letters* with Emma Hudgins as a co-author), and “Speed regulation of genetic cascades allows for evolvability in the body plan specification of insects” (published in *PNAS* with Paul François as a co-author).

Students and Postdoctoral Fellows

In 2016–2017 CAMBAM members supervised or co-supervised 13 M.Sc. students, 19 Ph.D. students, and 5 postdoctoral fellows.

Codirectors

Erik Cook and Frédéric Guichard (McGill)

Regular Members

Jacques Bélair, Alain Vinet (Montréal)

Pedro Peres-Neto (UQAM)

Mathieu Blanchette, David L. Buckeridge, Maurice Chacron, Vamsy Chodavarapu, Kathleen Cullen, Paul François, Gregor Fussman, Leon Glass, Michael Guevara, Anthony R. Humphries, Anmar Khadra, Svetlana V. Komarova, Brian Leung, Michael C. Mackey, Jacek Majewski, Sam Musallam, Christopher Pack (McGill)

André Longtin (Ottawa)

Associate Members

Fahima Nekka (Montréal)

Juli Atherton (UQAM)

Lea Popovic (Concordia)

Claire de Mazancourt, Michel Loreau
(Station d’Écologie Théorique et Expérimentale)

Moisés Santillán Zerón (Cinvestav)

Vincent Lemaire (Pfizer)

CICMA
Centre Interuniversitaire en calcul mathématique algébrique

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

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

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

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

Highlights

The 2016–2017 academic year was a particularly successful one for CICMA: the research programs of several of its members led to striking new results with a substantial impact on the international stage. Dimitris Koukoulopoulos actively pursued the development of the "pretentious approach" to analytic number theory initiated by Andrew Granville and K. Soundararajan. This new direction lays original foundations for large parts of the subject and attracted the interest of many other researchers throughout the world. Although Granville was on leave from Montreal, he maintained a strong research presence in CICMA through visits and ongoing collaborations; his scientific contributions were recognized in this period with the Wolfson Research Merit Award from the Royal Society of London and an ERC Advanced Research Grant in 2016, shortly after his election to the prestigious Academia Europaea in 2015.

Adrian Iovita's dramatic breakthroughs on the structure of Coleman-Mazur eigenvarieties and his proof of Robert Coleman's spectral halo conjecture (in collaboration with Andreatta and Pilloni) had a transformative impact on the theory of *p*-adic families of modular forms. They were recognized with an invitation to deliver an invited address at the ICM in Rio de Janeiro, along with Vincent Pilloni and Fabrizio Andreatta, a former CICMA postdoctoral fellow. Maksym Radziwiłł's landmark work with Kaisa Matomäki on cancellations of multiplicative functions in short intervals was widely hailed as perhaps the most significant development in analytic number theory of the past few years, worldwide. This work was the basis for a breakthrough with Terence Tao on the Erdős discrepancy problem. Radziwiłł's work was featured in several prestigious international seminars and gatherings, such as the Séminaire Bourbaki in Paris in 2016, and recognized by the awarding of the 2016 SASTRA Ramanujan Prize and a Sloan Fellowship in 2017.

Eyal Goren's monumental work with Andreatta, Howard, and Madapusi-Pera was another of the number theory highlights that were noticed around the world in 2016–2017. It supplies the key ingredient in one of the most significant breakthroughs in arithmetic geometry of the past decade: the proof of the Colmez conjecture on average and of the celebrated André–Oort conjecture. This work has now appeared in a 140-page article published in the Annals of Mathematics. Antonio Lei's groundbreaking work on Euler systems undertaken a few years ago (in collaboration with David Loeffler and Sarah Zerbes) continues to have a transformative impact on the theory of Euler systems, leading to a revival of the subject that was featured in particular at the EPFL in Lausanne in 2017 (where Lei delivered a well-attended mini-course and Henri Darmon served as a member of the organizing committee).

Henri Darmon's work with Victor Rotger on the Birch and Swinnerton-Dyer conjecture was the object of several semester-long working seminars, notably at Princeton and UCLA last year, and was recognized with the 2016 AMS Cole Prize in number theory and the 2017 CRM–Fields–PIMS Prize. In the winter of 2017, Jan Vonk (a current CICMA postdoc) and Darmon made a decisive step in the program to extend the 19th century theory of complex multiplication to real quadratic fields, discovering a convincing analogue of singular moduli in this setting.

Students and Postdoctoral Fellows

In 2016–2017 the members of CICMA supervised or cosupervised two undergraduate students, 23 M.Sc. students, 43 Ph.D. students, and 20 postdoctoral fellows.

Director

Henri Darmon (McGill)

Regular Members

Andrew Granville, Dimitris Koukoulopoulos, Matilde Lalín (Montréal)

Eyal Z. Goren, John Labute, Michael Makkai, Maksym Radziwiłł, Peter Russell (McGill)

Chris J. Cummins, Chantal David, David Ford, Adrian Iovita, Hershy Kisilevsky, John McKay (Concordia)

Hugo Chapdelaine, Jean-Marie De Koninck, Antonio Lei, Claude Levesque (Laval)

Damien Roy (Ottawa)

M. Ram Murty (Queen's)

David S. Dummit (Vermont)

Associate Members

Daniel Fiorilli, Abdellah Sebbar (Ottawa)

Payman L. Kassaei (King's College London)

CIRGET
Centre interuniversitaire de recherches en géométrie et topologie

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

CIRGET, based at UQAM, is composed of regular and 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. Two further domains are represented within CIRGET: algebraic geometry (through Steven Lu's and Peter Russell's work) and geometric group theory (through Daniel Wise's work).

The members of CIRGET organize several seminars in geometry and topology, symplectic topology, and geometric group theory, as well as the CIRGET Junior Seminar.

Highlights

The CIRGET welcomed three new regular members this year. Emmanuel Giroux, director CNRS of the UMI CRM, is a specialist in contact geometry. Egor Shelukhin, a new professor at the Université de Montréal and a former CIRGET postdoctoral fellow, is working on symplectic and contact topology and in geometric analysis. Liam Watson, former CIRGET student, now holds a Canada Research Chair in low dimensional topology at the Université de Sherbrooke. The Centre also welcomed two new associate members: Maia Fraser is a professor and researcher in symplectic geometry at the University of Ottawa and Marcin Sabok works in the field of geometric group theory and logic at McGill University. In 2016–2017, the Centre had the opportunity to welcome several scientific visitors (often in collaboration with the UMI CRM).

CIRGET is very proud of one of its students, Siyuan Lu, who was awarded the Carl Herz Prize for his article written in collaboration with professor Pengfei Guan ("Curvature estimates for immersed hypersurfaces in Riemannian manifolds") and published in *Inventiones mathematicae*. Mr. Lu is now a postdoctoral fellow at Rutgers University.

From the scientific point of view, CIRGET had a very busy year. The Centre organized three weekly seminars: a seminar on geometry and topology, a seminar on geometric group theory, and a symplectic seminar. Furthermore, the members of CIRGET were very involved in the scientific events that took place in Montréal. Vestislav Apostolov was the local organizer of the conference on differential geometry in honour of Claude Lebrun (July 5–9, 2016, UQAM). Sir Roger Penrose and Sir Simon Donaldson were among the lecturers. Baptiste Chantraine, a former CIRGET student and now a senior lecturer in Nantes, organized a mini-workshop on the spectral invariants in contact geometry at CIRGET from May 30 to June 4, 2016 (within the ANR cospin project).

Students and Postdoctoral Fellows

In 2016–2017 the members of CIRGET supervised or cosupervised 21 M.Sc. students, 32 Ph.D. students, and 16 postdoctoral fellows.

Director

Steven Boyer (UQAM)

Regular Members

Abraham Broer, Octav Cornea, François Lalonde, Iosif Polterovich, Egor Shelukhin (Montréal)

Vestislav Apostolov, Olivier Collin, André Joyal, Steven Lu, Mark Powell, Frédéric Rochon (UQAM)

Pengfei Guan, Jacques Hurtubise, Niky Kamran, Mikaël Pichot, Piotr Przytycki, Peter Russell, Johannes Walcher, Daniel T. Wise (McGill)

Virginie Charette, Liam Watson (Sherbrooke)

Emmanuel Giroux (UMI CRM)

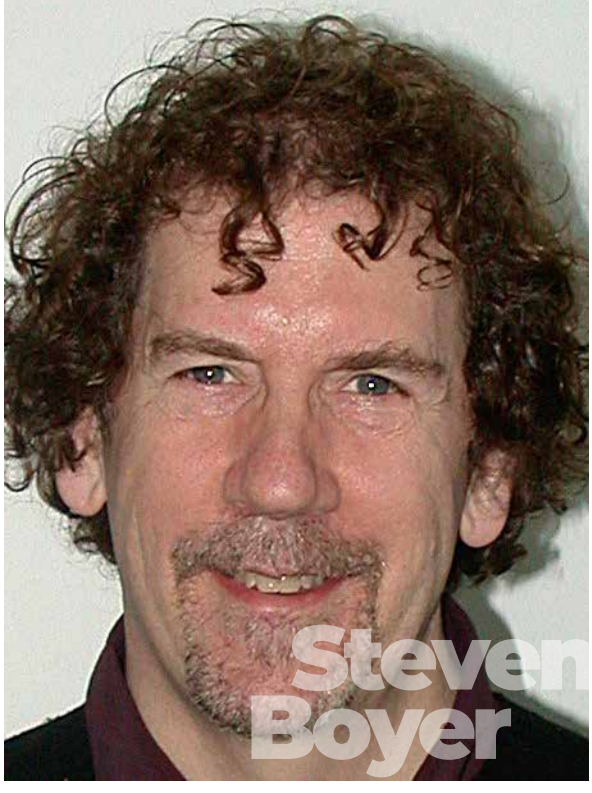
Associate Members

Dmitry Jakobson, Marcin Sabok, John A. Toth (McGill)

John Harnad (Concordia)

Maia Fraser (Ottawa)

Clément Hyvrier (Cégep de Saint-Laurent)



GIREF
Groupe Interdisciplinaire de Recherche en Éléments Finis

The recent advances in computer hardware and software allow researchers to model and simulate physical phenomena whose complexity is unheard of. These problems are characterized by non-linear laws, non-differentiable friction laws, large-deformation geometries, complex solid-solid or fluid-solid interactions, problems in multiphysics, etc. Such problems can be found everywhere in industrial environments, especially in the design and fabrication of high-technology products. Hence the members of GIREF (an acronym that means “Interdisciplinary Research Group in Finite Element Methods”) aim to develop original numerical methods for solving cutting-edge industrial problems in non-linear mechanics. Their work concerns pure mathematics, computer science, software engineering, and engineering. GIREF members propose general methods that can be used for diverse industrial applications.

GIREF organizes a regular seminar on the research areas of its members.

Highlights

The year 2016–2017 was a crucial one for GIREF regarding the long-term financing of its work. The second five-year term of the NSERC Industrial Chair held by A. Fortin (in which Michelin was an industrial partner) ended in October 2017. The GIREF is happy to announce that not only has the industrial chair been renewed for five years, but two researchers from GIREF (Professors J. Deteix and J. Urquiza) have received Collaborative Research and Development grants from NSERC. Two new industrial partners have been added to the Chair: Hydro-Québec and Bodycad, a company from Quebec City specializing in the design of biomedical implants. The grant amounts to approximately 5.5 million dollars for the five year period and covers the salaries of research personnel (two persons), grants for five postdoctoral fellows, and scholarships for 17 doctoral students, 12 master’s students, and 18 undergraduate students (summer jobs).

GIREF is an important partner of an NSERC CREATE grant of 1.6 million dollars entitled “Simulation-Based Engineering.” This grant allows graduate students to receive funding and help them travel between participating institutions (Université Laval, Université de Montréal, and University of Ottawa). In 2016–2017 GIREF participated in the design of a new orientation in mechanical engineering, which will be offered (gradually) starting in the Fall of 2018. This new orientation is the first of its kind in North America. Its goal is to provide chemical, mechanical, and aerospace engineers with mathematical and computer tools along with computational skills to use the distributed architecture of computers efficiently. In particular the travel grant has allowed Guillaume Émond, one of

the students, to benefit from the expertise of GIREF to develop successfully a variant of his finite element software for spectral finite elements. This software was developed, among other applications, for the study of the monolithic fluid-structure interaction by Professors Fortin and Garon.

Director
André Fortin (Laval)

Deputy Director
André Garon (Polytechnique Montréal)

Regular Members
Jean Deteix, Nicolas Doyon, Michel Fortin, Robert Guénette, Khader Khadraoui, Jean-Philippe Lessard, René Therrien, José Urquiza (Laval)

Associate Members
Michel Delfour (Montréal)

Alain Cloutier, Marie-Laure Dano, Claire Deschênes, Guy Dumas, Mathieu Olivier, Jean-Loup Robert, Seyed Mohammad Taghavi (Laval)

Stéphane Étienne, François Guilbault, Dominique Pelletier (Polytechnique Montréal)

Marie-Isabelle Farinas (UQAC)

Yves Secrétan (INRS-ETE)

Yves Bourgault (Ottawa)

Pietro-Luciano Buono (UOIT)

Mohamed Farhloul, Sophie Léger (Moncton)

Youssef Belhamadia (Université américaine de Sharjah)

Jean-François Hétu (CNRC-IMI)

LaCIM
Laboratoire de combinatoire et d'informatique mathématique

LaCIM is a research centre gathering researchers in mathematics and mathematical computer science working in algebraic combinatorics, discrete mathematics, and the mathematical aspects of computer science. LaCIM was founded in 1989 and includes regular members, postdoctoral researchers, and associate researchers. The regular members of LaCIM supervise, on their own or with collaborators, Ph.D. and M.Sc. students and summer interns (who are undergraduate students). The research interests of LaCIM members have broadened considerably since 1989: it is considered as one of the main research groups worldwide in algebraic combinatorics, enumerative combinatorics, and word combinatorics. Some LaCIM researchers work in bioinformatics and analysis of algorithms. The laboratory welcomes many visitors and researchers who are leaders in the subjects studied at LaCIM. The laboratory also maintains numerous collaborations with most of the great centres in combinatorics, especially centres in France, the United States, and Canada. The combinatorics and mathematical computer science seminar takes place each Friday at LaCIM, from September to June.

Highlights
In 2016–2017 LaCIM focused its efforts on the thematic semester on Algebra and Words in Combinatorics (see the section on the CRM thematic programs in the current report). The semester consisted of four periods of two weeks each: the first week was dedicated to a course and the second one consisted of a workshop on the same topic. In addition, three postgraduate courses were given by three professors from UQAM (respectively): Christophe Hohlweg, Christophe Reutenauer, and François Bergeron.

Four other lectures or workshops were organized by LaCIM researchers in 2016–2017. Srečko Brlek and Christophe Reutenauer were members of the program committee for the conference Developments in Language Theory 2016, held in Montréal on July 25–28, 2016. Alexandre Blondin Massé was a member of the organizing committee for this conference. Cédric Chauve and Sylvie Hamel were part of the organizing committee of the 14th RECOMB Comparative Genomics Satellite Workshop, held in Montréal on October 11–14, 2016. The 14th edition of the Combinatorial Algebra meets Algebraic Combinatorics workshop took place at UQAM on January 27–29, 2017 and Christophe Hohlweg, Franco Saliola, and Hugh Thomas were members of the organizing committee. François Bergeron and Christophe Reutenauer were invited to give lectures during this workshop. Finally, Christophe Hohlweg was one of the organizers of the 78th "Séminaire Lotharingien de Combinatoire" held in Ottrott (France) on March 26–29, 2017.

Students and Postdoctoral Fellows

In 2016–2017 the members of LaCIM supervised or cosupervised 21 M.Sc. students, 21 Ph.D. students, and 11 postdoctoral fellows.

Director

Christophe Hohlweg (UQAM)

Regular Members

Sylvie Hamel (Montréal)

Anne Bergeron, François Bergeron, Alexandre Blondin Massé, Srečko Brlek, Gilbert Labelle, Vladimir Makarenkov, Christophe Reutenauer, Franco Saliola, Hugh Thomas (UQAM)

Ibrahim Assem, Thomas Brüstle, Shiping Liu (Sherbrooke)

Benoît Larose (Champlain Regional College)

Cédric Chauve, Marni Mishna (Simon Fraser)

Associate Members

Odile Marcotte, Timothy Walsh (UQAM)

Aïda Ouangraoua (Sherbrooke)

Nantel Bergeron (York)

Xavier Provençal (Savoie Mont Blanc)

Vincent Pilaud (LIX)

Applied Mathematics

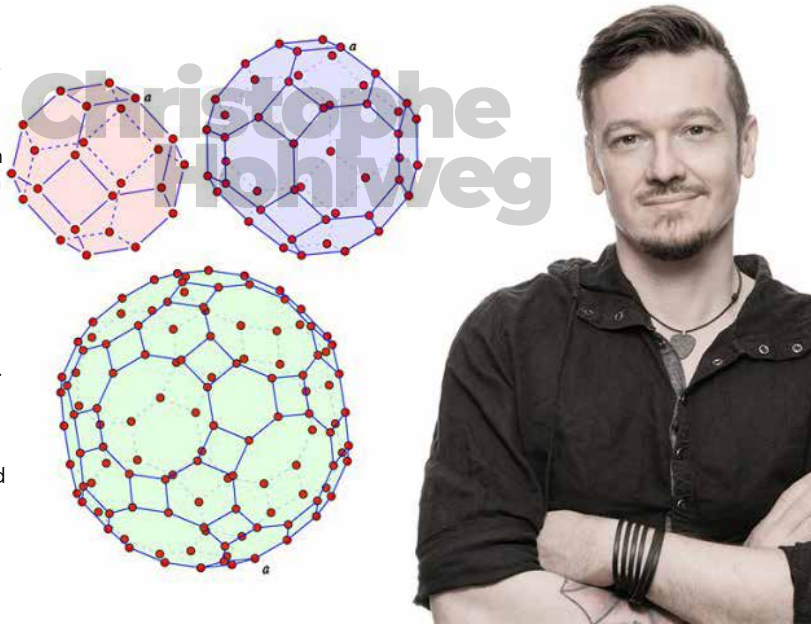
The Applied Mathematics Laboratory is a research network of around 20 applied mathematicians, engineers, computer scientists, and chemists, based in Montréal. The laboratory exists primarily to stimulate research and collaboration in the applied mathematical research areas of its members by fostering discussion and the creation of ideas through conferences, workshops, and seminars, and the furtherance of research through its visitors' program and the appointment of talented postdoctoral fellows. The laboratory is also very concerned with the training of young researchers and supports travel and conference attendance of its postdoctoral fellows.

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

Highlights

The Applied Mathematics Seminar featured a number of distinguished visitors, including James Burke (Washington), Michael Overton (Courant), Yury Grabovsky (Temple), Leon Glass (McGill), Andre Wibisino (Madison), Morgan Craig (Harvard), Jonathan Touboul (INRIA and Collège de France), and Dehua Wang (Pittsburgh). Long-term laboratory visitors included Pascal Poullet (Université des Antilles), who spent one year at the laboratory, and Pierre Maréchal (Toulouse), who spent one month. Laboratory members André Bandrauk and Emmanuel Lorin organized a workshop at BIRS Mexico on mathematical and numerical methods for time-dependent quantum mechanics.

Many of our members gave prestigious lectures. For example, Rustum Choksi was Semiplenary Speaker at the Second Mathematical Congress of the Americas (Montréal) and gave a series of lectures at the Ninth Summer School in Analysis and Applied Mathematics held in June 2017 at the Università di Roma La Sapienza. Adam Oberman gave invited lectures within conferences at Georgia Tech, BIRS Mexico, FoCM (Barcelona), the Courant Institute, the University of Maryland, and UCLA. Jean-Christophe Nave spoke at Waterloo, the Illinois Institute of Technology, and Shanghai. He was also awarded a prestigious Yinzhi Fellowship for a long-term visit at Jiao Tong University in Shanghai. André Bandrauk was awarded a position as Humboldt Foundation Visiting Scientist at the TH Münich and the Max-Born-Institut in Berlin. Laboratory members are on the editorial boards of premier research journals: for instance Rustum Choksi joined the Editorial Board of the *Journal of Nonlinear Science* and Adam Oberman the Editorial Board of *Mathematics of Computation*.



The Applied Mathematics Laboratory now includes a new faculty hire, Tim Hoheisel, a world expert in convex analysis and optimization, and a new postdoctoral fellow, Yann-Meing Law-Kam-Cio. Applied mathematics postdoctoral fellows David Shirokoff, Andy Wan, Xin Yang Lu, and Ihsan Topaloglu were awarded faculty positions at NJIT, Lakehead, UNBC, and Virginia Commonwealth (respectively). The laboratory supported Ph.D. student Tiago Salvador, who after graduation was awarded a three-year postdoctoral fellowship at the University of Michigan, Ann Arbor. Badal Yadav, a student supported by the laboratory during his M.Sc., was hired by Microsoft Azure, and Olivier Mercier (supported during his M.Sc. and Ph.D.) was hired by Oculus.

Students and Postdoctoral Fellows

In 2016–2017 the members of the Applied Mathematics Laboratory supervised or cosupervised 17 M.Sc. students, 29 Ph.D. students, and 7 postdoctoral fellows.

Director

Adam Oberman (McGill)

Regular Members

Jacques Bélair, Robert G. Owens (Montréal)

Peter Bartello, Peter Edwin Caines, Xiao-Wen Chang, Rustum Choksi, Antony R. Humphries, Jean-Christophe Nave, Bruce Shepherd, Gantumur Tsogtgerel, Adrian Vetta (McGill)

Eusebius J. Doedel (Concordia)

André D. Bandrauk (Sherbrooke)

Emmanuel Lorin (Carleton)

Associate Members

Sherwin A. Maslowe, Jian-Jun Xu (McGill)

Jean-Philippe Lessard (Laval)

MILA
(Institut des algorithmes d'apprentissage de Montréal)

MILA was founded by Professor Yoshua Bengio (Department of computer science and operations research, Université de Montréal). It includes around ten professors, almost 100 students, and around ten full-time employees (i.e., an Executive Director, a Team Lead in Software Infrastructure, six programmers, a financial agent, and an office coordination technician). The members of MILA have developed an impressive expertise in deep (discriminating or generative) networks and their applications in computer vision, speech modelling, and natural language processing. MILA has gained worldwide recognition for its numerous breakthroughs in the field of deep learning algorithms and their applications to many concrete problems (including, among others, the modelling of natural language, automatic translation, object recognition, generative models with structured output, and natural language recognition). The mission of MILA is to gather researchers in deep learning, to propose a platform for collaboration and student supervision, to pool human resources and computational clusters, and to facilitate technological transfer to companies wishing to benefit from machine learning algorithms.

The MILA seminars usually take place on Friday at the Université de Montréal. The seminars are given by MILA students or renowned researchers from other institutions or companies. The lecturers present their most recent discoveries. Each year MILA welcomes more than thirty invited lecturers.

Highlights

The excellence of MILA was confirmed in the past years through its significant advances in automatic learning, particularly with the theory and optimization of deep learning, reinforcement learning, statistical learning theory, unsupervised representations learning, graphic and generative models, recurrent neural networks, meta-learning or statistical inference techniques, structured prediction, and optimization. Furthermore, researches carried out to reduce the gap with the neurosciences have considerably progressed with the design of an "equilibrium propagation" algorithm, as presented in an article by B. Scellier and Y. Bengio. This algorithm rethinks the most widespread optimization algorithm in the field in order to mimic the way the human brain reasons.

Some of the discoveries of MILA in the medical field, one of its flagship fields, are about to enter hospitals thanks to Imagia, the start-up using deep networks to detect cancer cells. Natural language processing, another field where MILA excels, has reached a level of maturity that allows some of its applications to be marketed. For example, the Lyrebird start-up (originating at MILA) will market software imitating a human voice based on a short voice sample. Professor Bengio's laboratory, recognized on the international scene, has become one of the world's largest university research centres on deep learning. At the end of 2016, MILA's team was one of the 12 expert groups chosen (amongst hundreds of groups from 22 different countries) to take part in the Amazon Alexa Prize on

socialbots. It was the only Canadian team to qualify for the final round.

This stunning popularity attracts public and private investors who understand the huge potential of the new ecosystem promoted by MILA. Technology giants like Google, Microsoft, and Facebook have opened their own laboratories in Montréal to benefit from the proximity of MILA and contribute to joint research with MILA. The federal and provincial governments promised respectively 125 and 100 million dollars to support the Canadian and Quebec's communities in the field of artificial intelligence. Recognized as a non-profit organization since July 2017, MILA views its mission as widening. In addition to a cutting-edge research program, technology transfer has become one of its priorities, along with the development of an artificial intelligence that is both ethical and socially responsible. Professor Bengio's tireless dedication was recognized by Radio-Canada who declared him "Scientist of the year" in 2017.

Students and Postdoctoral Fellows

In 2016–2017 the members of MILA supervised or cosupervised 29 M.Sc. students, 42 Ph.D. students, and 12 postdoctoral fellows.

Director

Yoshua Bengio (Montréal)

Regular Members

Aaron Courville, Simon Lacoste-Julien, Roland Memisevic, Pascal Vincent (Montréal)

Christopher Pal (Polytechnique Montréal)

Laurent Charlin (HEC Montréal)

Doina Precup, Joëlle Pineau (McGill)

Associated Member

Alain Tapp (Montréal)

Mathematical Physics

The mathematical physics group is one of the oldest and most active at the CRM. It consists of around twenty regular members, around ten local associate members (all full-time faculty members at one of the participating universities), and close to ten 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 non-linear 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.

The laboratory organizes a regular mathematical physics seminar, held in general at the CRM on Tuesday afternoon.

Highlights

In 2016–2017 William Witzak-Krempa (Université de Montréal) and Simon Caron-Huot (McGill University) were elected as regular members of the Mathematical Physics Laboratory and Sarah Harrison (McGill University) and Ferenc Balogh (John Abbot College) became associate members of the laboratory. Several prizes, distinctions, and visiting professorships were awarded to members of the laboratory. For instance, Luc Vinet was named Officer of the Ordre national du Québec, William Witzak-Krempa was awarded a Tier 2 Canada Research Chair in Quantum Phase Transitions, and Simon Caron-Huot was awarded the Gribov Medal 2017 by the European Physical Society. Michel Grundland was a Visiting Professor at the Fondation Mathématique Jacques Hadamard in June 2016 and John Harnad was an invited researcher at IHES-IHP from January to June 2017. Laboratory members also organized conferences and workshops; in particular several members of the laboratory (Ferenc Balogh, Véronique Hussin, Decio Levi, Raphaël Verge-Rebelo, and Pavel Winternitz) were organizers of ASIDE (June 27–July 1, 2016) or SIDE12 (July 3–9, 2016), two events already mentioned in the section of the present report on the other activities of the CRM.

Laboratory members also gave many invited talks at international conferences. Here are some of them. Marco Bertola and John Harnad both gave invited talks at a workshop on Painlevé equations and discrete dynamics (BIRS, October 2–7, 2016). John Harnad and Dmitry Korotkin both gave invited talks at the 5th Workshop on Combinatorics of Moduli Spaces, Hurwitz Spaces and Cohomological Field Theories (Moscow, June 6–11, 2016). Robert Brandenberger was an invited speaker at a workshop on emergent space–time in quantum gravity and fundamental cosmology (Albert Einstein Institute, Germany, September 26–29, 2016). Jacques Hurtubise gave an invited talk at the Hitchin 70 Conference (Madrid, September 12–16, 2016) and another talk at a conference on complex geometry held at the ICTS Centre (Bangalore, March 20–25, 2017). Véronique Hussin gave an invited talk at the Quantum Fest 2016 Conference (Mexico City, October 17–21, 2016).

Students and Postdoctoral Fellows

In 2016–2017 the members of the Mathematical Physics Laboratory supervised or cosupervised 6 undergraduate students, 15 M.Sc. students, 35 Ph.D. students, and 12 postdoctoral fellows.

Director

John Harnad (Concordia)

Regular Members

Véronique Hussin, Manu B. Paranjape, Jiří Patera, Yvan Saint-Aubin, Luc Vinet, Pavel Winternitz (Montréal)

Robert Brandenberger, Keshav Dasgupta, Jacques Hurtubise, Alexander Maloney (McGill)

Marco Bertola, Richard L. Hall, Dmitry Korotkin (Concordia)

Pierre Mathieu (Laval)

Vasilisa Shramchenko (Sherbrooke)

Alfred Michel Grundland (UQTR)

Johannes Walcher (Heidelberg)

Associate Members

Alexander J. Hariton, François Lalonde, Igor Loutsenko, William Witczak-Krempa (Montréal)

Simon Caron-Huot, Sarah Harrison, Dmitry Jakobson, Vojkan Jakšić, Niky Kamran, John A. Toth (McGill)

Chris J. Cummins, Alexander Shnirelman (Concordia)

Stéphane Durand (Cégep Édouard-Montpetit)

Robert Conte, Bertrand Eynard (CEA-Saclay)

Jean-Pierre Gazeau (Paris Diderot)

Alexander R. Its (IUPUI)

Decio Levi (Roma Tre)

Robert Seiringer (IST Austria)

Alexander Turbiner (UNAM, Mexico)

Peter Zograf (Steklov Institute, Saint-Petersburg)

PhysNum

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

Fahima Nekka and her team conduct research in pharmacometrics, a discipline whose goal is to interpret and describe pharmacological phenomena in a quantitative manner, so as to support rational therapeutic decisions and improvement of patient health. They have developed a whole framework of probabilistic pharmacometrics in which different sources of variability and the non-linearity 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 designing tools that shed new light on drug development and evaluation, revisiting classical concepts in pharmacology and developing models for drug interactions.

Highlights

The PhysNum laboratory continued its activities related to applied mathematics in neurosciences and dynamic pharmacology. C. Grova is working in the field of inverse problems and localization of brain activity. J.-M. Lina is also working in this field, in collaboration with B. Torresani and M.-C. Roubaud (Aix-Marseille), who paid a visit at the CRM in 2016. J.-M. Lina is also doing research in multifractal analysis and electrophysiology with S. Jaffard (Paris-Est Créteil Val-de-Marne), P. Abry (CNRS, Physique ÉNS-Lyon), and H. Wendt (CNRS, IRIT). M. Descoteaux, who has held an institutional chair in neuroinformatics at the Université de Sherbrooke since April 1st, 2017, conducts research on inverse problems and information transfer in white matter fibers, in collaboration with J.-M. Lina. K. Jerbi works on deep learning and neurosciences; PhysNum also includes a postdoctoral researcher working in this field, Tarek Lajnef.

Fahima Nekka's research program concerns well-identified needs and major opportunities in drug research and development; it is based on solid theoretical foundations to provide quantification methodologies supporting rational therapeutic decisions and improvement of patient health. Her projects span many areas, including chemotherapy, HIV, ADHD, and antibiotics, and their results are being transferred to the public and immediate users under various forms: for example a web application for the treatment of ADHD, a platform to automatize the selection of a limited sampling strategy for immunosuppressants, and a Quantitative Systems Pharmacology approach to predict the risk of virological failure and the emergence of drug resistance in the treatment of HIV. Fahima Nekka organized a special session within the 19th European Conference on Mathematics for Industry (Santiago de Compostela, June 13–17, 2016): this session was entitled "Towards Translational Pharmacology: The Fair Share of Mathematical Sciences."

Students and Postdoctoral Fellows

In 2016–2017 PhysNum members supervised or cosupervised 17 M.Sc. students, 24 Ph.D. students, and 9 postdoctoral fellows.

Director

Jean-Marc Lina (ÉTS)

Regular Members

Karim Jerbi, Fahima Nekka (Montréal)

Frédéric Lesage (Polytechnique Montréal)

Habib Benali, Christophe Grova (Concordia)

Maxime Descoteaux (Sherbrooke)

Alain Arnéodo (Laboratoire de physique, ENS Lyon)

Montréal Probability Group

In 2014 the CRM ratified the creation of a new CRM laboratory in probability: the Montréal Probability Group. The research interests of the group span theoretical and applied, continuous and discrete probability. One important stream of research within the laboratory is the development and analysis of probabilistic models for physical, biological, statistical, and computational systems. The creation of this laboratory highlights the quality of probability research in the Montreal region and the recent influx of researchers in this area.

Highlights

Members of the laboratory co-organized the CRM thematic semester on Probabilistic Methods in Geometry, Topology and Spectral Theory (see the section on the CRM thematic programs). In particular they organized the following two workshops: Probabilistic Methods in Spectral Geometry and PDE (in August 2016); Random Growth Problems and Random Matrices (in September 2016). Lea Popovic was one of the organizers of the South Eastern Probability Conference 2017 (Durham, North Carolina): the topic of the conference was Interacting Particle Systems. She was also a member of the Program Committee of the World Congress of the Bernoulli Society/IMS Meeting (Toronto, July 2016).

The laboratory welcomed two new members: Jessica Lin, who was recruited as assistant professor at McGill, and Jean-Francois Coeurjolly from UQAM (who is also a member of the Statistics Laboratory). Janosch Ortmann became a new regular member of the laboratory after his recruitment at UQAM. Lea Popovic became the IMS Representative on the Joint Committee on Women in the Mathematical Sciences and an Associate Editor for *SIAM Review*. She was named a member of the evaluation group for the NSERC Discovery Grants Program.

Students and Postdoctoral Fellows

In 2016–2017 the members of the Montréal Probability Group supervised or cosupervised 10 M.Sc. students, 18 Ph.D. students, and 4 postdoctoral fellows.

Director
Lea Popovic (Concordia)

Regular Members
Alexander Fribergh, Sabin Lessard (Montréal)

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

Wei Sun, Xiaowen Zhou (Concordia)

Aaron Smith (Ottawa)

Donald A. Dawson (Carleton)

Louis-Pierre Arguin (Baruch College, CUNY)

Associate Members
Andrew Granville (Montréal)

Dmitry Jakobson, Vojkan Jakšić (McGill)

Marco Bertola (Concordia)

Quantact
Actuarial and Financial Mathematics Laboratory

Quantact is the name of the CRM Laboratory of Actuarial and Financial Mathematics, i.e., the area of mathematics concerned with problems in insurance and finance. The Laboratory members develop and use probabilistic and statistical methods to analyze issues having a financial impact on society. Quantact gathers professors from UQAM, Concordia University, Université Laval, and Université de Montréal.

The research interests of Quantact members include FADR insurance, actuarial statistics, actuarial finance, and mathematical finance, as well as the mathematics of risk and ruin theory. Here are a few of the themes studied by Quantact members: pricing and provisioning in FADR insurance; solvency of financial institutions; financial innovation in insurance (pricing and covering of variable annuities and market-linked insurance products); the modelling of longevity risk and mortality and their impacts on life insurance and pension schemes; the quantification of the impact of natural disasters and other extreme events; dependency models; measures of risk; models for the frequency and severity of disasters; stochastic control of risk processes and stochastic optimization; and the statistical analysis of big data in insurance.

Highlights
During the year 2016–2017, the Quantact laboratory of the CRM organized or co-organized approximately fifteen half-days of seminars with guest lecturers from Québec (Université Laval, HEC Montréal, etc.) and abroad (United States, Belgium, Portugal, etc.). Those activities took place at the Université Laval, the Université de Montréal, Concordia University, and UQAM.

On March 24, 2017, the Quantact laboratory also organized a thematic workshop on fire, accident, and other kinds of insurance (non-life insurance) at Concordia University. This workshop gathered 27 participants (students, professors, and industry representatives) and included three lectures, given respectively by researchers from McGill University, the University of Wisconsin-Madison, and KU Leuven. Finally the laboratory participated in the organization of the 6th Workshop for postgraduate students in actuarial sciences and financial mathematics (UQAM).

Students and Postdoctoral Fellows
In 2016–2017 the members of Quantact supervised or cosupervised 2 undergraduate students, 36 M.Sc. students, 17 Ph.D. students, and 7 postdoctoral fellows.

Director
Mathieu Boudreault (UQAM)

Regular Members
Maciej Augustyniak, Manuel Morales (Montréal)

Jean-Philippe Boucher, Arthur Charpentier, Anne MacKay, Mathieu Pigeon, Jean-François Renaud, Alexandre Roch (UQAM)

Patrice Gaillardetz, José Garrido, Cody Hyndman, Mélina Mailhot (Concordia)

Hélène Cossette, Étienne Marceau (Laval)

Chantal Labbé (HEC Montréal)

Statistics

Statistical methods and reasoning play an important role in the advancement of knowledge. Be it through surveys from sampling, the measure of socio-economic indicators, clinical trials to compare various biomedical treatments, or the study of the survival of an animal population in ecology, statistical methodology can be found everywhere in the sciences. Recently statistics has undergone a revolution in its techniques and approaches. This revolution has been driven by the need to analyze very large data sets and data with more complex structure, and by the advent of powerful computers. Statistical methodology is now addressing problems whose structure is very complex, such as the analysis of brain images or genome data, and new methodology (such as data mining) is being developed for large data sets. The computational aspect of statistics is thus becoming more and more important, but of course mathematics continues to be the foundation of statistics.

Statistics has many application areas and in particular the laboratory includes several researchers in biostatistics. One of the aims of the laboratory is to structure the Québec statistical community so that it can participate in the revolution mentioned above 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, as well as the newly created Canadian Statistical Sciences Institute (CANSSI). The laboratory consists 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.

The members of the Statistics Laboratory organize four regular seminars: the Statistics Seminars at McGill, Laval, and Sherbrooke, respectively, and the Biostatistics Seminar at the Université de Montréal.

Highlights

Several members of the Statistics Laboratory organized or co-organized high-level scientific meetings funded by the CRM and the laboratory, including the CRM Networking Industrial Workshop on Data Analysis, Modelling, and Decision-Making Support (organized by Thierry Duchesne at the Université Laval in January 2017), the Spring Meeting of Statlab (organized by Louis-Paul Rivest and Éric Marchand at the Université Laval in May 2017), a workshop on spatial point processes (organized by Jean-François Coeurjolly at UQAM in June 2017), a conference on the use of R in Quebec City (organized by Anne-Sophie Charest at the Université Laval), and a workshop on statistical hydrology (organized by Fateh Chebana in Quebec City in September 2016).

Many members of the Statistics Laboratory were honoured or given positions reflecting their competence and influence on the national and international scenes. Here are some examples. Robert Platt is President-Elect of the Statistical Society of Canada. Christian Genest is Editor-in-Chief of the *Journal of Multivariate Analysis*. Debbie Dupuis and Christian Léger have been elected “Fellow” of the American Statistical Association (ASA). Alexandra Schmidt received the Distinguished Achievement Medal of the “Statistics and the Environment” Section of the ASA. Yoshua Bengio was appointed Fellow of the Royal Society of Canada and Officer of the Order of Canada. For the third time, a Tier 1 Canada Research Chair was awarded to Louis-Paul Rivest.

The Statistics Laboratory organizes four regular seminars, as mentioned above. Overall, almost 80 lecturers gave presentations within those seminars in 2016–2017.

Students and Postdoctoral Fellows

In 2016–2017 the members of the Statistics Laboratory supervised or cosupervised 114 M.Sc. students, 102 Ph.D. students, and 27 postdoctoral fellows.

Director

Éric Marchand (Sherbrooke)

Regular Members

Jean-François Angers, Mylène Bédard, Yoshua Bengio, Martin Bilodeau, Pierre Duchesne, David Haziza, Christian Léger, Alejandro Murua, François Perron, Mireille Schnitzer (Montréal)

Juli Atherton, Jean-François Coeurjolly, Sorana Froda, Simon Guillotte, Fabrice Larribe, Geneviève Lefebvre, Brenda MacGibbon, Karim Oualkacha (UQAM)

Masoud Asgharian, Christian Genest, Abbas Khalili, Erica E. M. Moodie, Johanna Nešlehová, Robert W. Platt, James O. Ramsay, Paramita Saha Chaudhuri, Alexandra M. Schmidt, Russell Steele, David A. Stephens, David B. Wolfson (McGill)

Yogendra P. Chaubey, Arusharka Sen (Concordia)

Belkacem Abdous, Anne-Sophie Charest, Thierry Duchesne, Lajmi Lakhal Chaieb, Khader Khadraoui, Louis-Paul Rivest (Laval)

Taoufik Bouezmarni (Sherbrooke)

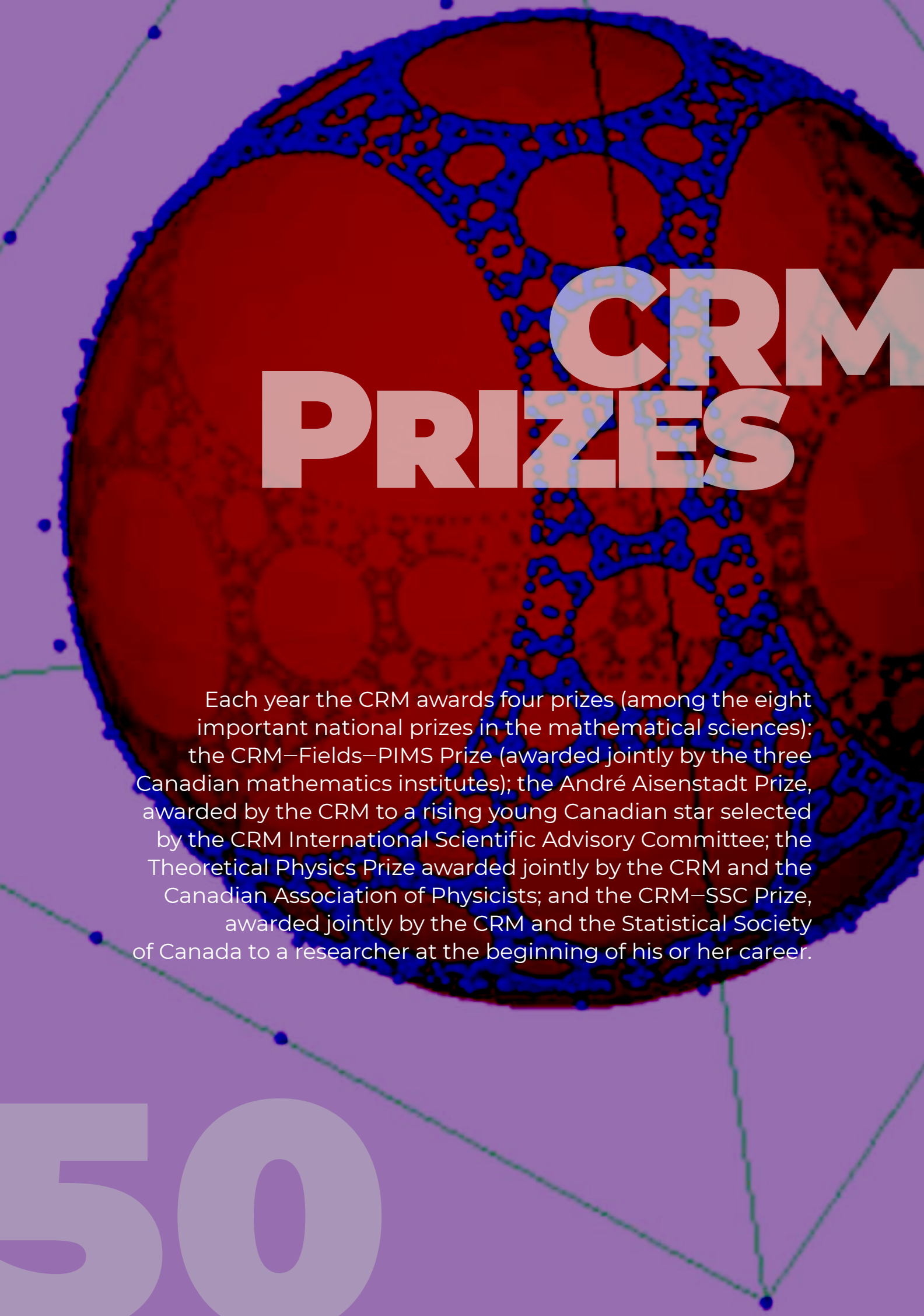
Vahid Partovi Nia (Polytechnique Montréal)

Debbie J. Dupuis, Aurélie Labbe, Bruno Rémillard (HEC Montréal)

Fateh Chebana (INRS-ETE)

Associate Member

Nadia Ghazzali (UQTR)



CRM Prizes

Each year the CRM awards four prizes (among the eight important national prizes in the mathematical sciences): the CRM–Fields–PIMS Prize (awarded jointly by the three Canadian mathematics institutes); the André Aisenstadt Prize, awarded by the CRM to a rising young Canadian star selected by the CRM International Scientific Advisory Committee; the Theoretical Physics Prize awarded jointly by the CRM and the Canadian Association of Physicists; and the CRM–SSC Prize, awarded jointly by the CRM and the Statistical Society of Canada to a researcher at the beginning of his or her career.

The CRM Prizes

The 2017 CRM–Fields–PIMS Prize Awarded to Henri Darmon

Professor Henri Darmon of McGill University is the winner of the 2017 CRM–Fields–PIMS Prize. Professor Darmon is one of the leading number theorists of his generation. He has an extraordinary record of deep and highly influential contributions to the arithmetic theory of elliptic curves, including his recent breakthrough on the Birch and Swinnerton-Dyer conjecture.

He has also been an exceptional mentor to students and an exemplary citizen of the mathematical community. Henri Darmon obtained his Ph.D. in mathematics from Harvard University in 1991. He has been James McGill Professor of Mathematics since 2005 and Fellow of the Royal Society of Canada since 2003.

The CRM–Fields–PIMS Prize

This prize was established in 1994 as the CRM–Fields Prize to recognize exceptional research in the mathematical sciences. In 2005 PIMS became an equal partner in the awarding of the prize and its name was changed to the CRM–Fields–PIMS Prize. A committee appointed by the three institutes chooses the recipient. The previous recipients of the prize are H.S.M. (Donald) Coxeter (1995), George A. Elliott (1996), James Arthur (1997), Robert V. Moody (1998), Stephen A. Cook (1999), Israel Michael Sigal (2000), William T. Tutte (2001), John B. Friedlander (2002), John McKay (2003), Edwin Perkins (2003), Donald A. Dawson (2004), David Boyd (2005), Nicole Tomczak-Jaegermann (2006), Joel S. Feldman (2007), Allan Borodin (2008), Martin Barlow (2009), Gordon Slade (2010), Marc Lewis (2011), Stevo Todorčević (2012), Bruce Reed (2013), Niky Kamran (2014), Kai Behrend (2015), and Daniel Wise (2016).

The 2017 André Aisenstadt Prize Awarded to Jacob Tsimerman

Just six years beyond his PhD, Jacob Tsimerman is an extraordinary mathematician whose work at the interface of transcendence theory, analytic number theory, and arithmetic geometry is remarkable for its creativity and insight.

Besides being a brilliant and innovative researcher, Tsimerman is also an excellent expositor and teacher. Moreover, he has been active in Math Outreach through his training of the Canadian team for the International Math Olympiad. He is currently the Chair of the Canadian IMO Committee.

The André Aisenstadt Prize

Created in 1991, the André Aisenstadt Mathematics Prize is intended to recognize and reward research achievements in pure and applied mathematics by talented young Canadian mathematicians. This prize consists of a $3,000 award and a medal. The recipient is chosen by the International Scientific Advisory Committee of the CRM. At the time of consideration, candidates must be Canadian citizens or permanent residents of Canada and no more than seven years from their Ph.D. The mathematician who is awarded this prize is invited to give a lecture at the CRM and present a summary of his or her work for publication in the Bulletin du CRM. The previous recipients of the André Aisenstadt Prize are Niky Kamran (1992), Ian Putnam (1993), Michael Ward (1995), Nigel Higson (1995), Adrian S. Lewis (1996), Lisa Jeffrey (1997), Henri Darmon (1997), Boris Khesin (1998), John Toth (1999), Changfeng Gui (2000), Eckhard Meinrenken (2001), Jinyi Chen (2002), Alexander Brudnyi (2003), Vinayak Vatsal (2004), Ravi Vakil (2005), Iosif Polterovich (2006), Tai-Peng Tsai (2006), Alexander E. Holroyd (2007), Gregory G. Smith (2007), József Solymosi (2008), Jonathan Taylor (2008), Valentin Blomer (2009), Omer Angel (2010), Joel Kamnitzer (2011), Marco Gualtieri (2012), Young-Heon Kim (2012), Spyros Alexakis (2013), Sabin Cautis (2014), Louis-Pierre Arguin (2015), and Anne Broadbent (2016).

The 2017 CAP–CRM Prize Awarded to Raymond Laflamme

Raymond Laflamme completed his Ph.D. on aspects of general relativity and quantum cosmology in the Department of Applied Mathematics and Theoretical Physics (DAMTP), under the direction of Professor Stephen Hawking at the University of Cambridge. From 1992 to 2001, Dr. Laflamme worked as a research scientist at the Los Alamos Research Laboratory, where his interests shifted from cosmology to quantum computing. His work in this new area has focused on how to make quantum information processors more feasible.

Dr. Laflamme holds the Canada Research Chair in Quantum Information and has authored or co-authored over 170 academic papers. He also co-authored a book, “Introduction to Quantum Computing,” with Michele Mosca and Philip Kaye in 2006. Dr. Laflamme founded the Institute for Quantum Computing in 2002 and has been its Executive Director since its inception.

The CAP–CRM Prize

The Centre de recherches mathématiques (CRM) and the Canadian Association of Physicists (CAP) created in 1995, on the occasion of the 50th anniversary of the CAP, a joint prize in recognition of exceptional achievements in theoretical and mathematical physics. The prize consists of a $3,000 award and a medal. The previous recipients of the ACP–CRM Prize are Werner Israel (1995), William G. Unruh (1996), Ian Affleck (1997), J. Richard Bond (1998), David J. Rowe (1999), Gordon W. Semenoff (2000), André-Marie Tremblay (2001), Pavel Winternitz (2002), Matthew Choptuik (2003), Jiří Patera (2004), Robert Myers (2005), John Harnad (2006), Joel S. Feldman (2007), Richard Cleve (2008), Hong Guo (2009), Clifford Burgess (2010), Robert Brandenberger (2011), Luc Vinet (2013), Mark Van Raamsdonk (2014), Charles Gale (2015), and Freddy Cachazo (2016).

The CRM–SSC Prize

The SSC, founded in 1977, is dedicated to the promotion of excellence in statistical research and practice. The prestigious CRM–SSC Prize is awarded each year to a Canadian statistician in recognition of outstanding contributions to the discipline during the recipient's first 15 years after earning a doctorate. The previous recipients of the CRM–SSC Prize are Christian Genest (1999), Robert J. Tibshirani (2000), Colleen D. Cutler (2001), Larry A. Wasserman (2002), Charmaine B. Dean (2003), Randy Sitter (2004), Jiahua Chen (2005), Jeffrey Rosenthal (2006), Richard Cook (2007), Paul Gustafson (2008), Hugh Chipman (2009), Grace Y. Yi (2010), Edward Susko (2011), Changbao Wu (2012), Derek Bingham (2013), Fang Yao (2014), Matías Salibián-Barrera (2015), and Radu Craiu (2016).

The 2017 CRM–SSC Prize Awarded to Lei Sun

Lei Sun obtained an undergraduate degree in mathematics from Fudan University in Shanghai. She received her PhD degree in statistics from the University of Chicago. Her thesis, supervised by Professor Mary-Sara McPeek, on "Two statistical problems in human genetics," launched her career in statistical genetics, a career for which she is now internationally renowned. Dr. Sun joined the University of Toronto in 2001 as an Assistant Professor in the Division of Biostatistics at the Dalla Lana School of Public Health. In 2014 she was promoted to Full Professor, with a joint appointment in the Department of Statistical Sciences and the Division of Biostatistics.

Professor Sun's research program investigates novel statistical methods and develops powerful computational tools for advancing understanding of the genetic basis of complex human traits. Her work has spurred new research directions in statistical methodology and has also been very influential in genetics research.

EDUCATION

A substantial part of the CRM activities are carried out in collaboration with the Institut des sciences mathématiques (ISM), which was created in 1991 and has eight partners: Bishop's University, Concordia University, McGill University, Université de Montréal, UQAM, UQTR, Université de Sherbrooke, and Université Laval. The ISM is financed by its partners and the Québec Ministry of Education. The ISM mission consists of: coordinating and harmonizing the mathematics graduate programs of Québec universities; fostering excellence in training; supporting research through scholarships and prizes; and stimulating the interest of young people for the mathematical sciences, in particular through the dissemination of mathematical knowledge among teachers, young people, and the general public. In 2016–2017 the director of the ISM was Professor Alina Stancu (Concordia University).

Education

CRM–ISM Postdoctoral Fellowships

The CRM–ISM Postdoctoral Fellowships allow promising young researchers to devote most of their time to their research work within the CRM and its partner institutions. The program is very competitive. Postdoctoral fellows collaborate with mature researchers, bringing new ideas from other great centres of mathematical research and organizing working groups on cutting-edge topics.

Here is the list of fellows, along with the institution and year of their PhD. We also give their research areas and the names of the mathematicians who supervised them at the CRM.

Jeffrey Galkowski
Ph.D.: University of California, Berkeley (2015)

Supervisors: Dmitry Jakobson and John Toth (McGill), Iosif Polterovich (Montréal)

Research area: mathematical analysis, geometry, and topology

Stephen Lester
Ph.D.: University of Rochester (2013)
Supervisors: Chantal David (Concordia), Dimitris Koukoulopoulos (Montréal), Maksym Radziwiłł (McGill)

Research area: algebra and number theory

Janosch Ortmann
Ph.D.: University of Warwick (2012)
Supervisors: Louigi Addario-Berry (McGill), Marco Bertola, John Harnad, and Lea Popovic (Concordia)
Research area: mathematical physics, probability

Rebecca Patrias
Ph.D.: University of Minnesota (2016)
Supervisors: Hugh Thomas and François Bergeron (UQAM)
Research area: combinatorics and mathematical computer science

Mattia Righetti
Ph.D.: Università di Genova (2016)
Supervisors: Dimitris Koukoulopoulos (Montréal), Maksym Radziwiłł (McGill)
Research area: algebra and number theory

Sanchayan Sen
Ph.D.: New York University (2014)
Supervisors: Louigi Addario-Berry (McGill), Alexander Fribergh (Montréal)
Research area: probability

Jan Volec
Ph.D.: University of Warwick & Université Paris Diderot (2014)
Supervisors: Sergey Norin and Hamed Hatami (McGill)
Research area: discrete mathematics and optimization

Undergraduate Summer Scholarships

In collaboration with the CRM and 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 or young professors.

Here is the list of undergraduate scholars for the summer of 2016.

David Ayotte (Laval)
Supervisor: Antonio Lei (young professor)
Project: Calculs numériques des nombres de classes

Amélie Compagna (Laval)
Supervisor: Jean Deteix (young professor)
Project: Étude comparative de schémas Runge–Kutta d'ordre 2 à 4 pour le modèle de Poisson–Nernst–Planck

Cem Gormezano (McGill)
Junior supervisor: Andy Wan (postdoctoral fellow)
Senior supervisor: Jean-Christophe Nave
Project: Conservative Discretizations for the Point Vortex Problem on the Plane

Daniel Hutama (McGill)
Junior supervisor: Stephen Ehlen (postdoctoral fellow)
Senior supervisor: Henri Darmon
Project: Primes in Arithmetic Progressions

Gabriel Lemyre (Montréal)
Supervisor: Maciej Augustyniak (young professor)
Project: Estimation du modèle à volatilité stochastique par l'entremise des modèles à chaîne de Markov cachée

Luis Ledesma Vega (McGill)
Junior supervisor: Yannick Bonthonneau (CRM–ISM postdoctoral fellow)
Senior supervisor: Dmitry Jakobson
Project: Eigenvectors of Elements in $Z(SU(2))$

Julia Levesque (Montréal)
Junior supervisor: Jean Lagacé (Ph.D. student)
Senior supervisor: Iosif Polterovich
Project: Spectre de Steklov sur des polygones et des polyèdres

Félix Lévesque-Desrosiers (Laval)
Supervisor: Nicolas Doyon (young professor)
Project: Propagation de la lumière dans des tissus : modèle de diffusion

Florence Maas-Gariépy (UQAM)
Junior supervisor: Nathan Williams (postdoctoral fellow)
Senior supervisor: Christophe Hohlweg
Project: Classification des sous-groupes finis de réflexions du plan et de l'espace

Lara Maleyeff (McGill)
Junior supervisor: Michael Wallace (postdoctoral fellow)
Senior supervisor: Erica Moodie
Project: Monte Carlo Sensitivity Analysis for Unmeasured Confounding

Mathieu Roussel-Lewis (McGill)
Junior supervisor: Xin Yang Lu (postdoctoral fellow)
Senior supervisor: Rustum Choksi
Project: Skill Matching in Optimal Transport

Scientific Activities

XXe Colloque panquébécois des étudiants de l'ISM
May 12–14, 2017, UQTR

60e Congrès de l'Association mathématique du Québec
October 14–15, 2016, Cégep Garneau

Promotion of the Mathematical Sciences

The **Accromαth** magazine is produced by the ISM and its production costs are defrayed in part by the CRM. The magazine has two issues per year and is distributed free of charge in all Québec high schools and cégeps. The goal of **Accromαth** is to stimulate the high school and cégep teachers by providing them with material that is topical and up-to-date. **Accromαth** consists of articles on the most recent developments in mathematics and its applications, as well as articles on the history of mathematics or links between mathematics and the arts. **Accromαth** has been awarded several prizes (both for its contents and graphic design).

The CRM and the ISM jointly support the "Sciences et mathématiques en action" program (created by Professor Jean-Marie De Koninck) and the "Association québécoise des jeux mathématiques."

Graduate Students Supervision

The CRM members supervise a large number of graduate students. We now give information on the students supervised by CRM members who graduated in 2016–2017. The name of the student is followed by the name of his or her supervisor (or names of his or her supervisors). Some names may be missing from this list, because we have only included those that have been brought to our attention.

Students who obtained their Ph.D. in 2016–2017

Anas Abdallah (Jean-Philippe Boucher, Hélène Cossette)
Sadoune Ait Kaci Azzou (Sorana Froda, Fabrice Larribe)
Mathias Beaupeux (Paul François)
Malek Ben Abdellatif (Bruno Rémillard, Hatem Ben Ameur)
Billel Benzaid (Miklós Csűrös, Nadia El-Mabrouk)
Francesca Bergamaschi (Eyal Z. Goren, Adrian Iovita)
Guillaume Bonnefois (Fahima Nekka, Jun Li)
Xing Shi Cai (Luc Devroye)
Maxime Chamberland (Maxime Descoteaux, Kevin Whittingstall, David Fortin)
Rim Chérif (Bruno Rémillard, Hatem Ben Ameur)
Rasheda Arman Chowdhury (Christophe Grova)
Simon Chu (Payman L. Kassaei, Fred Diamond)
Marc-Alexandre Côté (Maxime Descoteaux, Hugo Larochelle)
Félix Desrochers-Guérin (Peter Russell, Steven Shin-Yi Lu)
Laura Clementina Eslava Fernandez (Louigi Addario-Berry)
Sara Ann Froehlich (Niky Kamran)
Shan Gao (Adrian Iovita)
Ashkan Golzar (Erik Cook)
Sonia Grandi (Robert W. Platt)
Aurélien Guetsop Nangue (Martin Bilodeau, Pierre Duchesne)
Renato Henriques da Silva (Pedro Peres-Neto)
Colin Jauffret (Abraham Broer)
Eva Kardhashi (Anne Bourlioux, Marc Laforest)
Marica Knezevic (Payman L. Kassaei, Fred Diamond)
Florent Kpodjedo (Bruno Rémillard, Michèle Breton)
Manuel Lafond (Nadia El-Mabrouk)

Kangjoo Lee (Christophe Grova)
Omid Makhmali (Niky Kamran)
Evan McDonough (Robert Brandenberger, Keshav Dasgupta)
Patrick Meisner (Chantal David)
Philippe Miron (André Garon)
Nasheed Moqueet (Robert W. Platt)
Kathryn Morrison (David L. Buckeridge)
Cheikh B. Ndongo (Raluca M. Balan)
Hedvig Nenzen (Pedro Peres-Neto, Dominique Gravel)
Ali Pakniyat (Peter Edwin Caines)
Ke Peng (Frédéric Lesage)
Joël Sango (Pierre Duchesne)
Andrew Smith (Pedro Peres-Neto)
Anush Stepanyan (Javad Mashreghi)
Hugo Tremblay (Srečko Brlek, Alexandre Blondin Massé)
Akshaa Vatwani (M. Ram Murty)
David Warde-Farley (Yoshua Bengio)
Peng-Jie Wong (M. Ram Murty)
Daniel Woodhouse (Daniel T. Wise)
Julian Z. Xue (Frédéric Guichard, André Costopoulos)
Iraj Yadegari (François Perron, Éric Marchand)
Jing Zhang II (Wei Sun)
Cong Zhang (Frédéric Lesage)
Petr Zorin (Richard L. Hall)

Students who obtained their M.Sc. in 2016–2017

Mouhammed Anwar Al Ghabra (Virginie Charette)
Ashwag Al Zahrani (José Garrido, Mélina Mailhot)
Jean-François Arbour (Frédéric Rochon)
Nadia Arrouf (Geneviève Lefebvre, Lucie Blais)
Assaf Shaul Bar-Natan (Piotr Przytycki)
Véronique Bazier-Matte (Ibrahim Assem)
Gabriel Beauchamp Houde (Matilde Lalín)
Nicholas Beck (José Garrido, Mélina Mailhot)
Christopher Beckham (Christopher J. Pal)
Lucas Berry (José Garrido, Mélina Mailhot)
Marc-André Bérubé (Pierre Blanchet)
Leila Bourmouche (René Ferland, Juli Atherton)
Russel Butler (Maxime Descoteaux)
Myriam Chabot (Éric Marchand)
Mohamed Amine Chouiref (Alexandru Badescu)
Scott Collier (Alexander Maloney)
Antoine Comeau-Lapointe (Dimitris Koukoulopoulos)
Steven Côté (Jean-Philippe Boucher)
Julien Courtois (Christiane Rousseau)
Martin Cousineau (Maxime Descoteaux)
Jie Dai (Xiaowen Zhou)
Aleksander Danielski (Alexander Shnirelman)
Golsa Dehghan (Aurélie Labbe)
Francis Demers (Claude Bélisle)
Magatte Diagne (Pascal Vincent)
Olivier Duquette (André Garon)
Samia El-Khoury (Patrice Gaillardetz)
Abdelhakim Ferradji (Fabrice Larribe, Karim Oualkacha)
Leesa Fleury (Alexander Maloney)
Pierre-Louis Gagnon (Hassan Manouzi)
Alexandre Gauvin (Maxime Descoteaux)
Yan Gobeil (Robert Brandenberger, Alexander Maloney)
Jonathan Godin (Dmitry Jakobson, Mikaël Pichot)
Jonathan Grégoire (Mathieu Boudreault)
Fabio Orlando Guacaneme Castiblanco (Mathieu Boudreault)
Hui Shan Huang (René Ferland)
Alexia Jolicoeur-Martineau (Russell Steele, Geneviève Lefebvre)
Arpita Kar (M. Ram Murty)
Megbe Karamoko (Louis-Paul Rivest)
Shamal Chandra Karmaker (Yogendra P. Chaubey, Lisa Kakinami)
Kyle Kastner (Yoshua Bengio, Roland Memisevic)
Rachid Kharoubi (Karim Oualkacha)
Fangahagnian Koné (Christian Léger, Martin Bilodeau)
Youcef Korichi (Hugo Chapdelaine)
Marc-Antoine Labrie (Jérémie Rostand, Alexandre Girouard)
Clara Lacroce (Adrian Iovita)
Simon Lalancette (Lajmi Lakhal Chaieb)
Mélodie Lapointe (Christophe Reutenauer, Alexandre Blondin Massé)
Sébastien Lavigne (Christophe Reutenauer)
Hao (Billy) Lee (Henri Darmon)
Isabelle Lefebvre (David Haziza)
Mehrnoosh Malekiha (Arusharka Sen)
Jean-François Marceau (Thomas Brüstle)
Julien Massé Jodoin (Frédéric Guichard)
Soroush Mehri (Yoshua Bengio, Aaron Courville)
Hanane Miftah (Aurélie Labbe, Karim Oualkacha)
Mouna Mokaddem (Alain Tapp, Pascal Vincent)
Hughes Moreau (Dominic Rochon)
Audrey Morin (Octav Cornea)
Erin Murray (Nadia Hardy)
Sandra Maria Nawar (José Garrido, Mélina Mailhot)
Erfan Nazari Zahraei Motlagh (Niky Kamran)
Mouhamed Niang (Étienne Marceau, Hélène Cossette)
Geneviève Nolze Charron (Maxime Descoteaux)
Pierre Claver Nsanzamahoro (Virginie Charette)
Lukasz Obara (Alexey Kokotov)
Maéva Ostermann (Thomas J. Ransford)
Vincent Ouellet (Jean-Marie De Koninck, Nicolas Doyon)
Sébastien Ouimet (Christophe Hohlweg)
Ibrahima Ousmane Ida (Louis-Paul Rivest)
Robert Pettus (François Bergeron)
Liam Peuckert (Lea Popovic)
Huy Hoang Minh Pham (Lajmi Lakhal Chaieb)
Romanic Pieugueu (Louis-Paul Rivest)
François Rheault (Maxime Descoteaux)
Guillaume Rochefort Maranda (Anne-Sophie Charest)
Kenza Sallier (Pierre Duchesne)
Parastoo Sepidband (Sorana Froda)
Samira Shabanian (Yoshua Bengio)
Jiequn Shen (Xiao-Wen Chang)
Shan Shi (Arusharka Sen)
Forte Shinko (Piotr Przytycki, Marcin Krzysztof Sabok)
Christopher Smith (Piotr Przytycki)
Abdoulaye Sonko (Alexandru Badescu)
Tianze Su (Xiao-Wen Chang, Benoit Champagne)
Pier-Olivier Tremblay (Thierry Duchesne)
Shardul Vikram (Alina Stancu)
Nhat Linh Vu (Arusharka Sen, Xiaowen Zhou)
Adam Wilks (Piotr Przytycki)
Xi Yuan (Bruce) Yin (Jean-Christophe Nave, Linan Chen)
Justine Zehr (Christian Léger)
Leila Zerrouk (Jean-Philippe Boucher, Simon Guillotte)
Dongliang Zhang (Masoud Asgharian, Abbas Khalili)
Meng Zhao (Russell Steele)
Jing Zhu (Xiao-Wen Chang)
Jeremie Zumer (Aaron Courville)

PARTNERSHIPS

Although the CRM is primarily concerned with mathematical research and training taking place within Québec, its activities are part of a broad framework and it collaborates with many partners to fulfill its mission and ensure that the research carried out in Québec is of international calibre.

Partnerships

Canadian Partnerships

On the Canadian scene the most important partnership of the CRM is the one with the two other Canadian mathematics institutes, i.e., the Fields Institute for Research in Mathematical Sciences (FI), based in Toronto, and the Pacific Institute for the Mathematical Sciences (PIMS) in the West. The three institutes coordinate their scientific activities (particularly their thematic programs) and have carried out several projects together, including the creation of networks such as Mitacs (see below) and the creation of the CRM–Fields–PIMS Prize. The three institutes also support some activities of the professional associations in the mathematical sciences and give some financial support to the Atlantic Association for Research in the Mathematical Sciences (AARMS), founded in 1996 to encourage and promote research in the mathematical sciences in the Atlantic provinces. The three institutes also support the Canadian Statistical Sciences Institute (CANSSI), whose aim is to develop statistical sciences in Canada through attracting new researchers to the field, increasing the points of contact among researchers nationally and internationally, and fostering collaborations with other disciplines and organizations. Finally the CRM is a partner of the Banff International Research Station (BIRS), which organizes workshops in mathematics all year round.

International Partnerships

The CRM members have many fruitful collaborations with French researchers, in particular those working at the *Centre national de la recherche scientifique* (CNRS), the *Institut national de recherche en informatique et automatique* (INRIA), and the *Institut national de la santé et de la recherche médicale* (INSERM). In March 2015 the CRM signed agreements with two prestigious French institutes: IHÉS (Institut des Hautes Études Scientifiques) and IHP (Institut Henri Poincaré). The CRM has signed a formal agreement with the ALGANT consortium (Algebra, Geometry, Number Theory) within the Erasmus Mundus network of the European Union. This agreement stimulates exchanges and joint supervision of graduate students. Finally we mention that the National Science Foundation (NSF) of the United States provides some financial support for almost every thematic program organized by the CRM.

L'Unité Mixte Internationale (UMI) du CNRS au CRM

A few years ago the *Centre National de la Recherche Scientifique* (CNRS) in France decided to create at the CRM a so-called UMI (i.e., a research unit outside of France). The official name of this UMI is "Centre de recherches mathématiques – UMI 3457" and it was inaugurated in October 2011. This UMI is extremely successful, thanks to the outstanding work of its first director, Laurent Habsieger, and its current director, Professor Emmanuel Giroux (CNRS Research Director). The UMI gives financial support to French researchers so that they can visit the CRM for long or short periods of time. It also supports visits to France by Québec researchers who spend a few weeks in France or are given temporary positions. The UMI provides financial support for the organization of meetings and workshops, either directly or through the reimbursement of lecturers' expenses (for instance). In this manner the UMI supports the activities of the CRM thematic programs and other activities.

When the President of France visited Québec in November 2014, the CNRS and the FRQNT signed an agreement providing for the financial support (by Québec) of Québec researchers visiting French laboratories (called "*sites miroirs*") for periods of two to six months. The Québec researchers in question must be affiliated with one of the three UMIs located in Québec universities. In particular this agreement allows members of the CRM to visit France in order to work with their French colleagues.

Academic Partners

The CRM has six academic partners: the Université de Montréal, McGill University, UQAM, Concordia University, the Université Laval, and the Université de Sherbrooke. The Department of Mathematics and Statistics of the University of Ottawa became a partner of the CRM in 2003. The CRM finances teaching releases so that University of Ottawa researchers can work in the CRM laboratories and take part in its scientific activities. The CRM also supports postdoctoral fellows at the University of Ottawa and finances the CRM–University of Ottawa Distinguished Lecture Series, which features talks by prominent mathematicians from Canada and abroad on topics at the forefront of mathematical research.

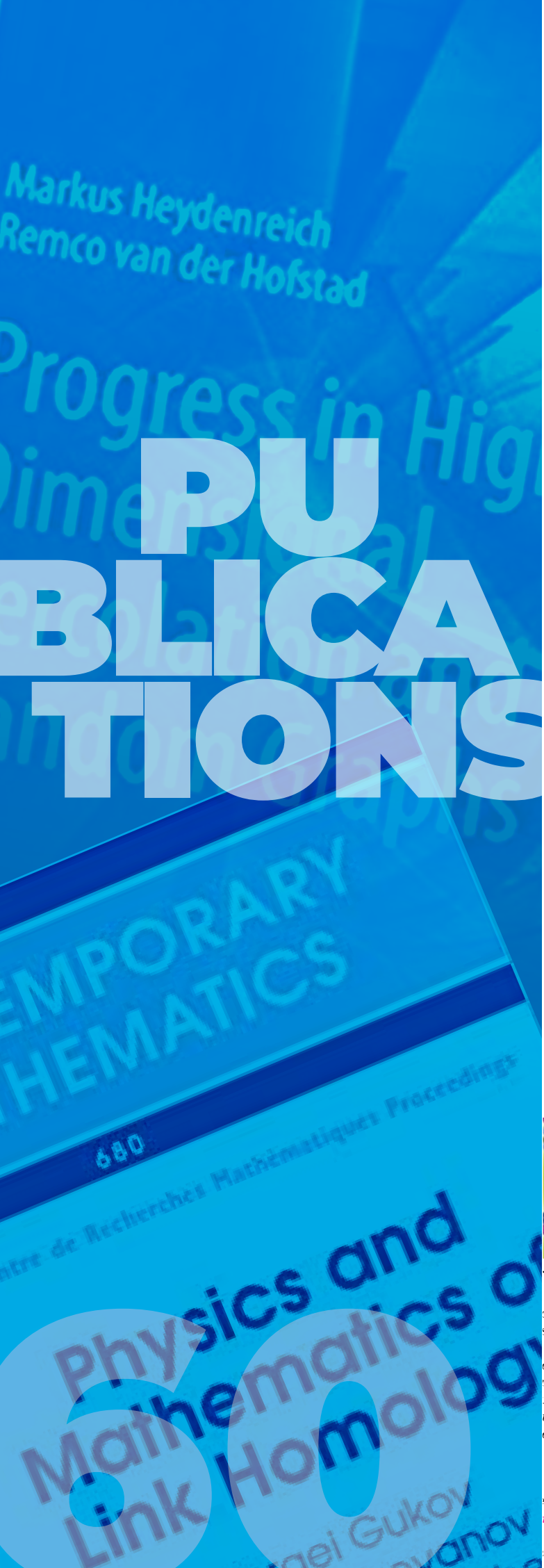
Collaborations with Research Networks

The CRM has created, on its own or with other institutes, research networks that promote collaborations in the mathematical sciences between universities and industry. In 1997 the CRM (whose director was Luc Vinet) created the Network for Computing and Mathematical Modeling (ncm_2), a consortium of research centres in the Montréal area. The ncm_2, which was funded by NSERC, was able to respond to the needs of industry in a wide variety of fields related to computing and mathematical modelling. At the present time it allows four research centres (the CRM, GERAD, CIRRELT, and CIRANO) to fund joint projects in the mathematical sciences.

The three Canadian mathematics institutes (the CRM, the Fields Institute, and PIMS) launched the Mitacs network in 1999, thanks to a grant from the Canadian government. The objective of Mitacs, the only network of centres of excellence in the mathematical sciences, was to channel Canadian efforts in designing, applying, and commercializing new mathematical tools and methodologies within the framework of a world-class research program. Mitacs was extremely successful: in particular it has involved up to 300 researchers and 600 students in around 50 Canadian universities. In 2011 Mitacs broadened the scope of its activities and the "mathematics" section of Mitacs was taken over by the Mprime network (from 2011 to 2014). Since Mprime does not exist anymore, the creation and fostering of CRM/industry partnerships is now taking place within the framework of the Institutes Innovation Platform (IIP), a project of the three Canadian mathematics institutes funded by NSERC and mentioned elsewhere in this report.

Collaborations with Professional Societies

The CRM and the other Canadian mathematics institutes give some financial support for the organization of the meetings of Canadian societies in the mathematical sciences. In particular, in 2016–2017, the CRM supported the Summer Meeting of the Canadian Mathematical Society (Edmonton, June 24–27, 2016), the Winter Meeting of the CMS (Niagara Falls, December 2–5, 2016), the Annual Meeting of the Statistical Society of Canada (St. Catharines, May 29–June 1st, 2016), and the Annual meeting of the Canadian Applied and Industrial Mathematics Society (Edmonton, June 26–30, 2016).



Publications

Publications are an important component of the contribution of the CRM to the dissemination of research in the mathematical sciences. The CRM has two long-standing series published in collaboration with the American Mathematical Society (AMS): the CRM Monograph Series and the CRM Proceedings (formerly CRM Proceedings and Lecture Notes), that have been included in Contemporary Mathematics since 2013. Springer publishes and distributes the CRM Series in Mathematical Physics, and a few titles from the CRM were included in its Lecture Notes in Statistics series. The first volumes of a new series (entitled CRM Short Courses) appeared in 2017. Although most of the books issued by the CRM are now to be found in these various series, the CRM also publishes and distributes, in French and in English, through *Les Publications du CRM*, monographs, proceedings, and lecture notes. In addition, the CRM occasionally takes part in joint projects with various publishers and distributes preprints of articles written by its researchers.

The CRM publishes *Le Bulletin du CRM* twice a year. This newsletter, consisting of between 20 and 30 pages, includes news from the CRM and articles on its activities and the research of its members and prize winners.

2016–2017 Publications

CRM Proceedings (subseries of Contemporary Mathematics)

Alexandre Girouard, Dmitry Jakobson, Michael Levitin, Nilima Nigam, Iosif Polterovich, and Frédéric Rochon (eds.), *Geometric and Computational Spectral Theory, 2016*.

CRM Series in Mathematical Physics

Decio Levi, Raphaël Verge-Rebelo, and Pavel Winternitz (eds.), *Symmetries and Integrability of Difference Equations, 2017*.

CRM Short Courses

Markus Heydenreich and Remco van der Hofstad, *Progress in High-Dimensional Percolation and Random Graphs, 2017*.

Governance & Scientific Guidance

The CRM structure consists of a Board of Directors, an Assembly of Members, an International Scientific Advisory Committee, a Local Scientific Committee, a Management Committee, an Industrial Committee, and a Committee of Directors of Laboratories. Here are the members of these committees in 2016–2017 (except for the directors of laboratories, already mentioned in a previous section).

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 director of a laboratory, nominated by the Committee of Directors of Laboratories, for a two-year mandate, normally renewable once;
- The president of the International Scientific Advisory Committee;
- A postdoctoral member;
- The Vice-principals, Research, of the six partner universities of the CRM (or their representatives);
- Additional members nominated by the Board of Directors, with or without the right to vote, from any relevant sector: business or industry sector, major Canadian or foreign research institutions, and public sector.

In 2016–2017, the Board members were Luc Vinet (Director of the CRM), Odile Marcotte (Deputy Director of the CRM), Christiane Rousseau and Jacques Bélair (both from the Université de Montréal), Steven Boyer (Director of CIRGET), Gérard Ben Arous (Chair of the International Scientific Advisory Committee), Rebecca Patrias (postdoctoral fellow), Marie-Josée Hébert (Vice-principal, Research, Université de Montréal), Justin Powlowski (Vice-principal, Research, Concordia University), Jacques Hurtubise for Rosie Goldstein (Vice-principal, Research, McGill University), Catherine Mounier (Vice-principal, Research, UQAM), Edwin Bourget then Angelo Tremblay (Vice-principal, Research, Université Laval), Jacques Beauvais (Vice-principal, Research, Université de Sherbrooke), Alina Stancu (Director of the ISM), Hélène Desmarais, and Luis Seco.

Louigi Addario-Berry (McGill) and Galia Dafni (Concordia), Deputy Directors of the CRM, were invited members of the Board of Directors. .

International Scientific Advisory Committee

The International Scientific Advisory Committee (ISAC) consists of outstanding Canadian or foreign researchers who are either mathematicians or scientists with close links to the mathematical sciences. The main task of the Committee is to make recommendations on the general scientific orientations of the CRM and give advice on proposed scientific activities. In 2016–2017 this committee was chaired by Gérard Ben Arous (Courant Institute) and also included Michael Bennett (University of British Columbia), Ruth Charney (Brandeis University), Stephen E. Fienberg (Carnegie Mellon University), Emmanuel Giroux (CNRS), Claude Le Bris (École des Ponts ParisTech), Dusa McDuff (Columbia University), Robert Pego (Carnegie Mellon University), Duong Phong (Columbia University), Dana Randall (Georgia Institute of Technology), Nicolai Reshetikhin (University of California, Berkeley), Emmanuel Ullmo (Institut des hautes études scientifiques), and Luc Vinet (Director of the CRM).

Louigi Addario-Berry, Galia Dafni, and Odile Marcotte (Deputy Directors of the CRM) were invited members of ISAC.

Local Scientific Committee

In 2016–2017, the Local Scientific Committee included Louigi Addario-Berry (McGill), Vestislav Apostolov (UQAM), Octav Cornea (Montréal), Jean-Philippe Lessard (Laval), Erica E. M. Moodie (McGill), Lea Popovic (Concordia), and Luc Vinet (Director of the CRM).

Management Committee

The Management Committee of the CRM consisted of Luc Vinet (Montréal), Director of the CRM, Louigi Addario-Berry (McGill), Deputy Director, Scientific Programming, Galia Dafni (Concordia), Deputy Director, Publications, and Odile Marcotte (UQAM and GERAD), Deputy Director, Partnerships.

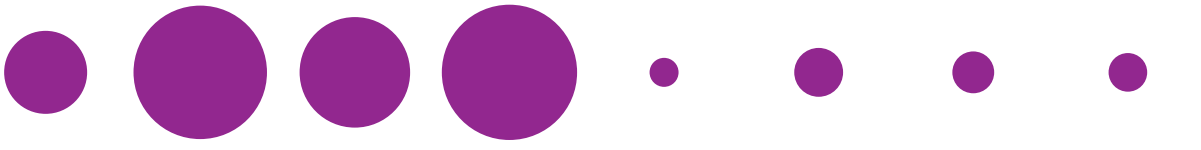
Industrial Committee

In 2016–2017, the Industrial Committee included Luc Vinet (Director of the CRM), Odile Marcotte (Deputy Director, Partnerships), Michel Carreau (Hatch), Denis Faubert (CRIAQ), Pierre Trudeau (GIRO), and Roxana Zangor (Pratt & Whitney).

THE CRM IN NUMBER

Sources of funding in 2016-2017
in thousands of $

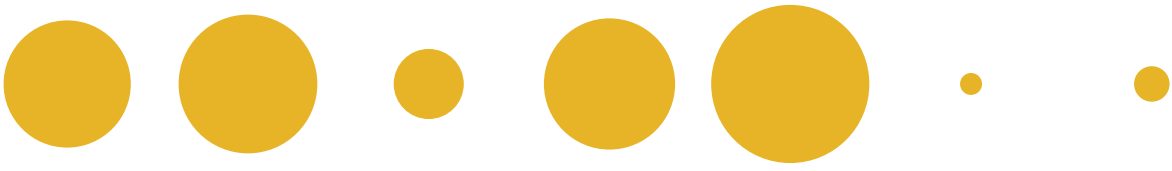
FRQNT	**508**
NSERC	**1 314**
Universities (funding)	**901**
Universities (in-kind)	**1 350**
Endowments	**62**
Sales and registration fees	**176**
Other grants	**129**
Partner organizations	**110**
	4 550



FRQNT | NSERC | Universities (funding) | Universities (in-kind) | Endowments | Sales and registr. fees | Other grants | Partner organizations

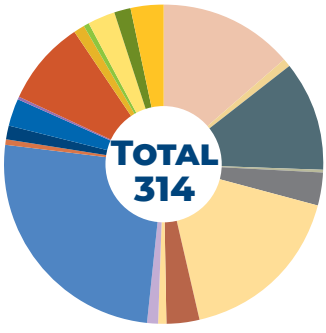
Use of funds
in thousands of $

Laboratories	**873**
Programs	**1 039**
Postdoctoral fellows	**265**
Management and staff	**929**
Spaces and services (universities)	**1 350**
Communications	**26**
Operating costs	**68**
	4 550



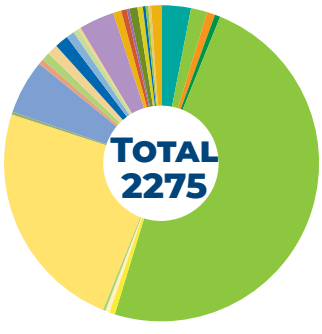
Laboratories | Programs | Postdoctoral fellows | Management and staff | Spaces and services (universities) | Communications | Operating costs

Affiliation of the regular and associate members (researchers) of the CRM and its laboratories



Université Laval	42	INRS	2
Université du Québec à Trois-Rivières	3	HEC Montréal	4
Université du Québec à Montréal	35	École Polytechnique de Montréal	9
Université du Québec à Chicoutimi	1	École de Technologie Supérieure	1
Université de Sherbrooke	10	Concordia University	27
Université de Montréal	54	CNRS (France)	3
University of Ottawa	11	Others, Mexique	2
Québec, Industry	2	Others, Europe	9
Québec, Colleges	4	Others, United States	5
McGill University	79	Others, Canada	11

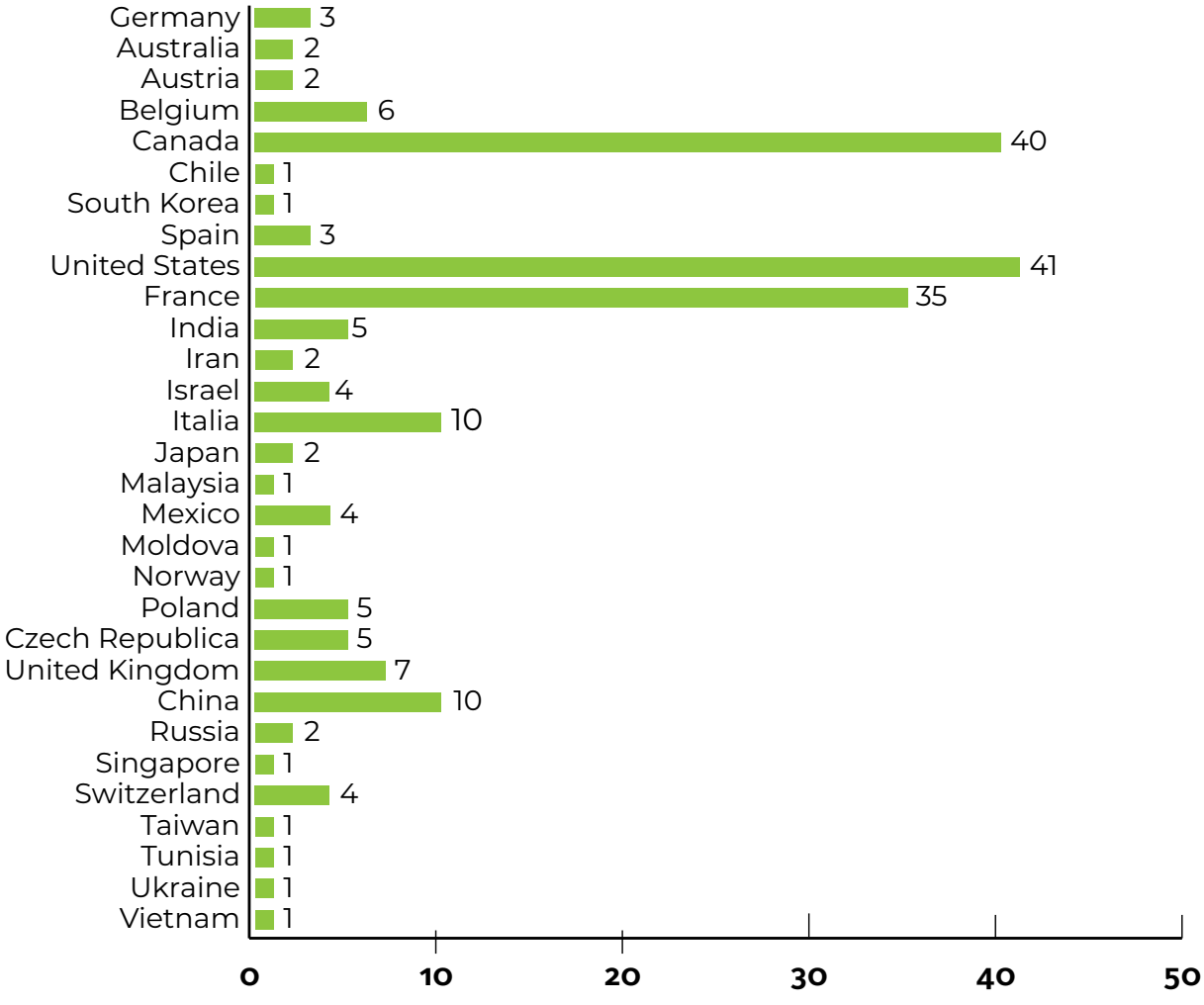
Country of origin of participants in CRM activities



Germany	68	Japan	32
Australia and New Zeland	35	Netherlands	17
Austria	21	Poland	15
Belgium	15	Czech Republic	7
Canada	1104	United Kingdom	77
South Korea	12	China	22
Denmark	13	Russia	13
Spain	8	Sweden	8
United States	539	Switzerland	19
Finland	8	Taiwan	8
France	127	Other, Africa	7
India	11	Other, Americas	11
Israel	23	Other, Asia	6
Italy	23	Other, Europe	26

THE CRM IN NUMBERS

Country of origin of visiting and postdoctoral researchers (202)



CRM Administrative and Support Staff

Director's Office

Luc Vinet	Université de Montréal Director
Louigi Addario-Berry	Université McGill Deputy Director – Scientific Programming
Galia Dafni	Concordia University Deputy Director – Publications
Odile Marcotte	UQAM and GERAD Deputy Director – Partnerships

Administration

Vincent Masciotra	Head of Administration
Guillermo Martinez-Zalce	Research Laboratories Coordinator
Diane Brulé-De Filippis	Administrative Assistant
Lucie Vincent	Secretary
Wendy Barrientos	Administrative Assistant

Scientific Activities

Louis Pelletier	Coordinator
Louise Letendre	Administrative Assistant
Sakina Benhima	Project Manager
Guillermo Martinez-Zalce	Research Laboratories Coordinator

Computer Services

Daniel Ouimet	Systems Administrator
André Montpetit	Office Systems Manager (half-time)

Publications

André Montpetit	TeX Expert (half-time)

Communications

Suzette Paradis	Communications Officer and Webmaster

Special Projects

Stéphane Rouillon	Partnerships Development Officer

CENTRE
DE RECHERCHES
MATHÉMATIQUES

CRM, Université de Montréal
C.P. 6128, succursale Centre-ville, Montréal (Québec) H3C 3J7 Canada
☎ 514-343-7501 🖷 514-343-2254 ✉ crm@crm.umontreal.ca

www.crm.math.ca