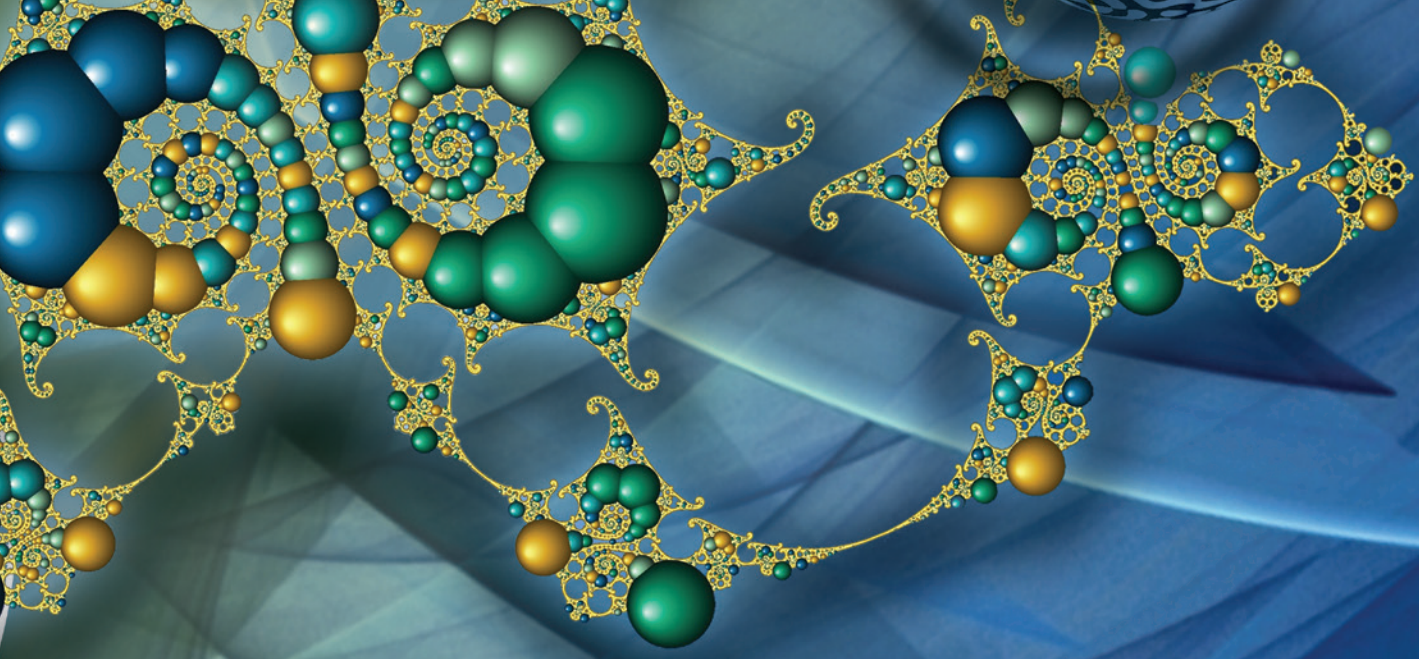
CENTRE
DE RECHERCHES
MATHÉMATIQUES

2018-2020 ANNUAL REPORT



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Introduction

The following report is an exceptional overview of the whole period from June 2018 to May 2020, two full and long years of activities. It was an eventful period for the CRM. Indeed, it enabled us to continue with the commemoration of its 50th anniversary, which started in March 2018 and ran through to November 2019. The program has been extremely rich, and we draw a global as well as an in-depth picture of this in a separate section of the present report. For its closing conference, the CRM hosted Persi Diaconis, who delivered a public lecture attracting several invited guests and a wide range of participants from various backgrounds.

It is worth noting that the attendance at the CRM of a large number of selected researchers from the Simons-CRM researchers' program was an important component of this program. A section of this report provides a list of all the researchers present at the CRM as part of this commemoration, but also includes those who have been working with CRM members in a broader context.

Of course, in March 2020, the COVID-19 pandemic seriously impacted our workings. Some events were canceled or rescheduled. Nevertheless, we have been able to quickly re-engineer ourselves. We have experienced the benefits (and drawbacks) of teleworking for both the administrative staff and the researchers. In the report, we highlight the activities that would not have been possible otherwise in a remarkably short timeframe, thanks to the technical support made available to us. We learned a lot under the circumstances, and we continue to learn every day.

It is worth noting the continuity of the CRM's achievements in the fields that are precious to it, such as organizing major public conferences, the presence of many Aisenstadt Chair scientists within the framework of thematic programs, the collaboration with many institutions and organizations for the awarding of several prizes, as well as a very active publication program. Most notably, the CRM acknowledges the contribution of its researchers in the thirteen laboratories, which constitute an essential component of its mission.

We would like to take this opportunity to thank the editorial team of this report, composed of Zahra Bensaddek, Laïla Oubenaïssa, Pierre Lavallée and Josée Leclerc. We would also like to acknowledge the contribution of the administrative staff of the CRM, who provided us with many relevant elements for this work.

Véronique Hussin
Deputy head, publications and communications

CRSNG NSERC
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CRM 50TH ANNIVERSARY PROGRAM

To mark its 50th anniversary, the CRM delivered a diverse and extensive scientific program which had a significant impact on mathematical sciences research. It was run over 18 months (from March 2018 to november 2019). The program consisted of a theme-based semester and 14 intensive month-long program sessions on high interest topics as well as several activities of shorter duration. A major feature of this program was the attendance at the CRM of scholars selected from the Simons-CRM scholars program.

The Thematic semester “Mathematical Challenges in N-body Physics and Quantum Information” was conducted from september to december 2018. The intensive monthly programs were aimed at fostering breakthroughs and new partnerships in mathematical research at the cutting edge of mathematical research.

The following is a summary table of the program. We then elaborate on the details of the activities conducted from June 2018 to the reporting period of November 2019.

Table summarizing the program for the 50th anniversary of the CRM

2018

Thematic programs

Thematic semester

Mathematical Challenges in N-body Physics and Quantum Computing

Aisenstadt Chairs Lecture Series

Many-Body Quantum Mechanics (10-14 Sept)

Entanglement, Integrability and Topology in Many-Body Systems (17-21 Sept)

CRM-PCTS Workshop on Critical Phenomena in Statistical Mechanics and Quantum Field Theory (3-5 Oct)

Quantum Information and Quantum Statistical Mechanics (15-19 Oct)

School on Mathematics of Non-Equilibrium Statistical Mechanics, on the occasion of the sixtieth birthday of Claude-Alain Pillet (24-26 Oct)

Entropic Fluctuation Relations in Mathematics and Physics (29 Oct-2 Nov)

Spectral Theory of Quasi-Periodic and Random Operators (12-16 Nov)

Monthly intensive programs

Mathematics of Machine Learning (14 April-11 May)

Probability in Number Theory (14 May-1 June)

Causal Inference in the Presence of Dependence and Network Structure (11 June-6 July)

Algebra, Combinatorics, and Mathematical Computer Science (17 Sept-14 Oct)

Others activities and events

Conference (launch of activities):

"Mathematics, Science and Technology, a new deal" by Jean-Pierre Bourguignon, President of the European Research Council and former President of the French Mathematical Society and of the European Mathematical Society (EMS) (9 March)

Nirenberg Workshop and Lectures on "Geometric Analysis" with Eugenia Malinnikova:

- "Frequency function and unique continuation" (12 March)
- "Application of the frequency function to the study of nodal sets" (14 March)
- "Remez inequality, unique continuation and propagation of smallness for second order elliptic PDEs" (16 March)

Workshop: A Celebration of CICMA's Postdoctoral Program (2-6 July)

Montreal Summer Workshop on Challenges in Probability and Mathematical Physics (9-20 July)

XIX International Congress of Mathematical Physics (ICMP 2018) (23-28 July)

2019

Thematic programs

Monthly intensive programs

New Developments in Free Probability and Applications (1-31 March)

Topological and Rigorous Computational Methods for High Dimensional Dynamics (1-26 April)

Faces of Integrability Program (29 April-17 May)

Data Assimilation: Theory, Algorithms, and Applications (8-29 May)

Homological Algebra, Microlocal Analysis and Symplectic Geometry (1-30 June)

Expansions, Lie Algebras and Invariants (1-31 July)

Quiver Varieties and Representation Theory (1-31 August)

Low-Dimensional Topology (1-31 August)

Mixed Integer Nonlinear Programming: Theory and Computation (1-31 Oct)

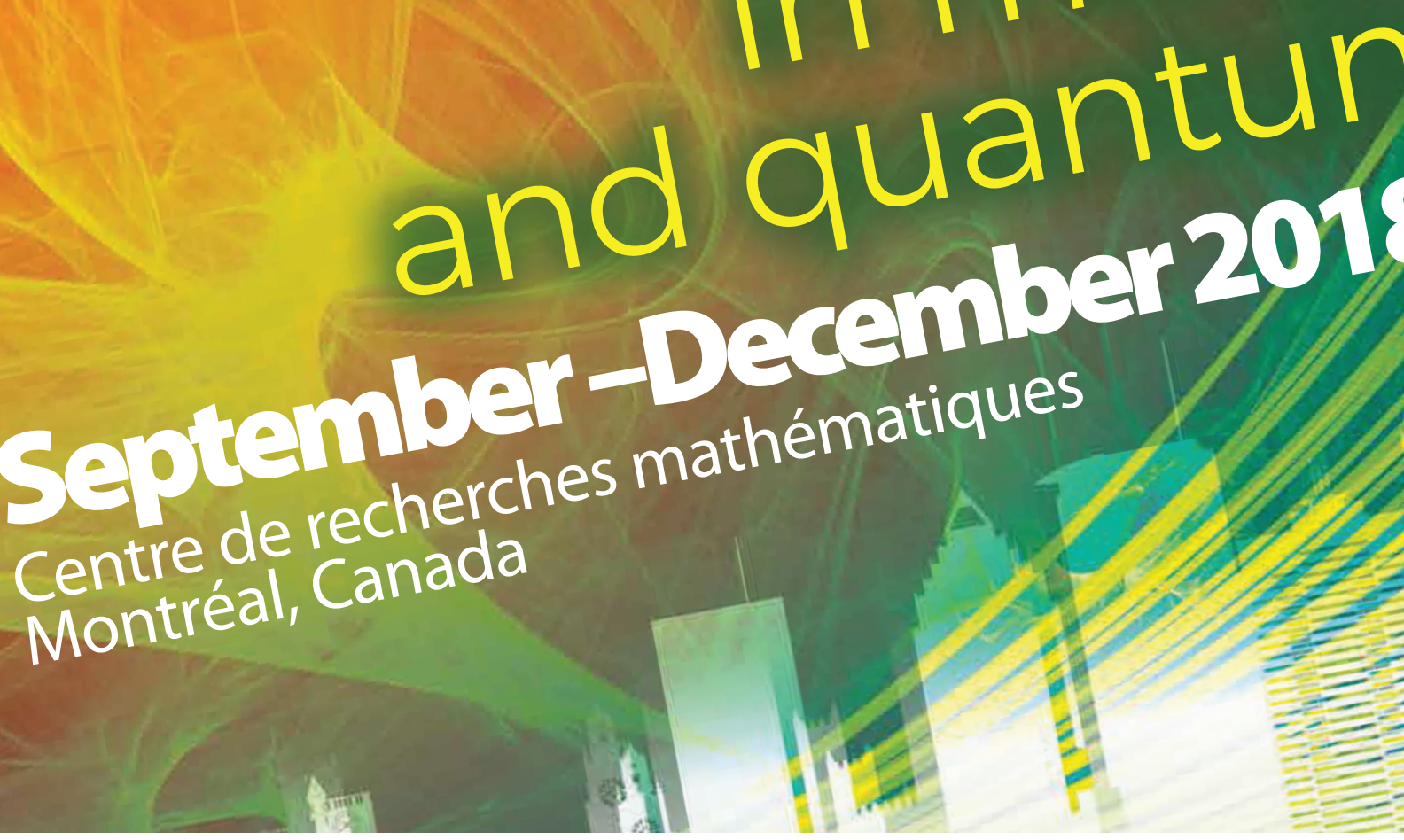
Mathematical Physiology – Better Health Through Mathematics (1-30 Nov)

Others activities and events

Workshop: "New Trends in Polynomial Differential Systems" (3-7 Sept)

Closing of the CRM's 50th anniversary celebration. Public conference:

Persi Diaconis "Adding numbers and shuffling cards" a public conference (27 Nov)



THEMATIC SEMESTER

Mathematical Challenges in N-body Physics and Quantum Computing

September-December 2018

Local organizing committee: *Jacques Hurtubise (McGill University); Dmitry Jakobson (McGill University); Vojkan Jakšić (McGill University); Dmitry Korotkin (Concordia); Luc Vinet (Montréal)*

The opening conferences of the thematic program were the 19th International Congress on Mathematical Physics and the parallel satellite meetings (www.ICMP2018.org). During the period September to December, six workshops were hosted at the CRM and a joint CRM-Princeton workshop was held in Princeton. Long-term participants gave daily seminars and mini-courses in-between workshops.

The activities of the thematic semester are outlined in the following.

Aisenstadt Chairs Lecture Series

(the proceedings of the lectures can be found in the corresponding section of this report)

Robert Seiringer (IST Austria):
10, 12 and 13 September 2018

Michael Aizenman (Princeton University):
24, 25 and 27 September 2018

Svetlana Jitomirskaya (UC Irvine):
12-13 November 2018

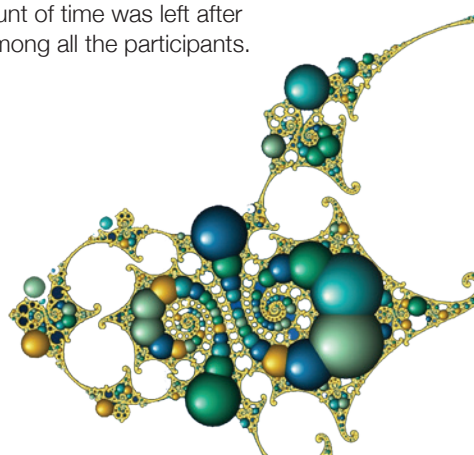
Workshop series

10-14 September 2018
Many-Body Quantum Mechanics

Organizers: *Rupert L. Frank (California Institute of Technology); Mathieu Lewin (Université Paris Dauphine);Benjamin Schlein (Universität Zürich*)

In recent years, considerable progress has been achieved in the mathematical analysis of N-body quantum systems. The main objective of the workshop was to gather researchers involved in different issues concerning N-body quantum mechanics, to share ideas on the latest advancements and propose new challenges and new research avenues. The core issues of the workshop concerned the derivation of effective equations; disordered N-body systems; open quantum systems in and out of equilibrium and quantum spin systems.

The total number of participants in the workshop was about 40, including 10 young researchers (graduate students and postdoc). In addition to normal talks delivered by some of these young participants, a special session was scheduled on Tuesday afternoon to allow other young participants to present their results in 20 min. Otherwise, all the talks were of the same length (40 min), with no distinction between young and more senior participants. A sufficient amount of time was left after lunch to foster discussions among all the participants.



17-21 September 2018
Entanglement, Integrability and Topology in Many-Body Systems

Organizers: *Paul Fendley (University of Oxford); Israel Klich (University of Virginia)*

This workshop brought together practitioners from mathematics and physics to exchange information and ideas related to these developments. A special focus was on precisely solvable systems, where the entanglement behavior can be investigated, which could ultimately lead to rigorous mathematical results.

Many exciting talks were presented and as well fruitful discussion and opportunity to bring together various subjects from both mathematics and physics. A good mix of junior and more senior researchers were attending. One main topic was many-body entanglement, with talks by Karyn Le Hur (CNRS), Kun Yang (NHMFL), Roger Melko (Waterloo), and Erik Tonni (SISSA).

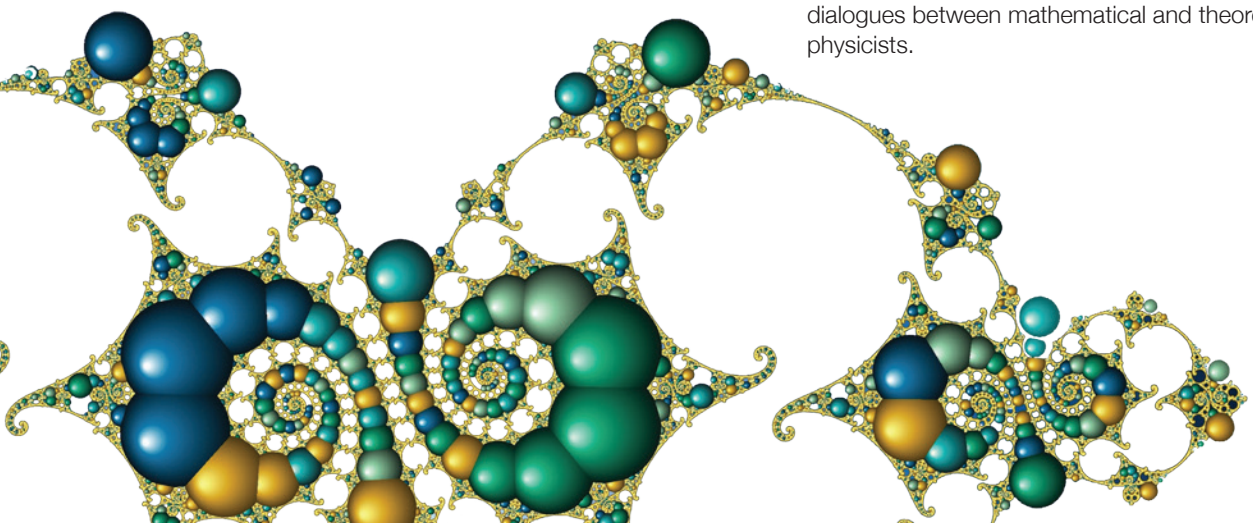
3-5 October 2018
CRM-PCTS Workshop on Critical Phenomena in Statistical Mechanics and Quantum Field Theory

Organizers: *Michael Aizenman (Princeton University); David Brydges (University of British Columbia); Igor Klebanov (Princeton University); Silviu Pufu (Princeton University)*

This workshop took place at Princeton Center for Theoretical Science (PCTS, Jadwin Hall, Princeton University).

The workshop's aim was to bring together a diverse group of researchers, who are working on related topics approached at different levels of rigor. Speakers were invited from among the leaders in their fields. However, participation in the workshop, and in the discussions which took place there, was open to all. The workshop was very successful in bringing together scientists who work in different countries and different professional subcultures, and thematic groups which do not meet regularly. In addition to the workshop's 16 lectures, it also featured a Physics Department colloquium. The latter had an even broader attendance, and nicely fulfilled the role of introducing a wider audience to the themes of the workshop.

The talks were recorded, and the videos and slides are available at the PCTS web site. They covered a remarkable range of topics, including rigorous approaches to quantum measurement (Jaksic), pedagogical presentations of rigorous methods (Brydges, Peled, Mastropietro, Porta, Bourgade), recent progress on large N tensor models (Gurau, Rivasseau, Schaposnik), new ideas concerning anomalies in QTF (Witten) and quantum gravity (Maldacena, Sheffield), and theory aiming to explain the recent experiments on the magic angles in twisted bilayer graphene (Tarnopolsky). The latter talk included a prediction of the value of the second magic angle, which is being searched for experimentally. To summarize, the workshop was a success. It provided updates on research in several cutting-edge directions and established interesting dialogues between mathematical and theoretical physicists.



15-19 October 2018
Quantum Information and Quantum Statistical Mechanics

Organizers: *Fernando G.S.L. Brandão (Caltech); Bruno Nachtergaele (UC Davis); Claude-Alain Pillet (Université du Sud Toulon-Var); Michael M. Wolf (Technische Universität München)*

This workshop brought together leading researchers in Quantum Computing Theory (QCT) and Statistical Quantum Mechanics (SQM) and emphasised ground state gap phases, dynamics and equilibrium, area laws, and entanglement and localisation with N-bodies.

Many speakers presented very recent and often not yet published work. Together, they presented a snap-shot of the current directions in quantum-many body research in action. The talks covered all the big themes in today's research within the scope of the workshop: quantum spin systems, spectral gaps, quantum entropy, entanglement and coherence, dynamics and non-equilibrium, disordered systems and localization, classification of phases, and topological states of matter and indices.

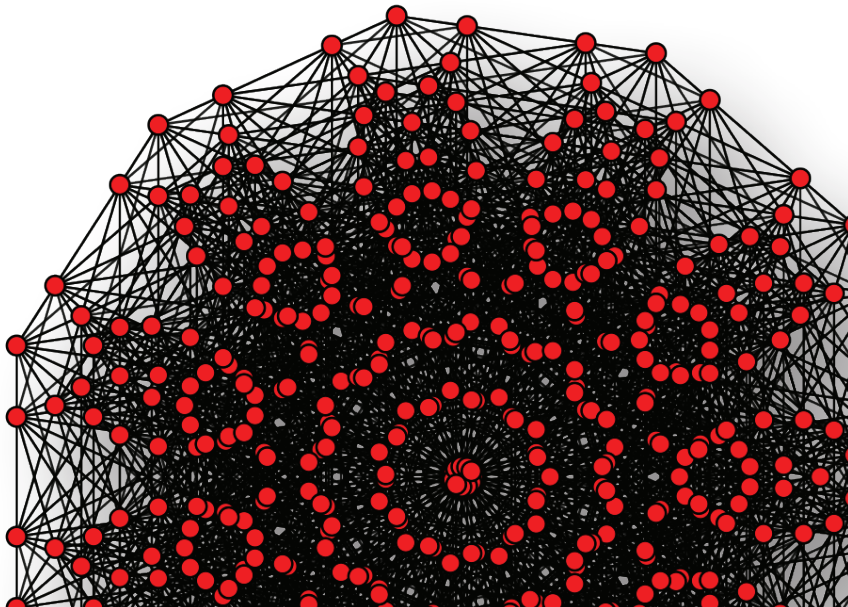
The workshop accomplished its goal of providing a forum for the exchange of ideas and cross-fertilization of the broad range of techniques researchers are developing to study the mathematical properties of interacting quantum systems. The connections between different approaches were illuminated in the talks and perhaps even more in the intense discussions that developed during the breaks between talks. Interactions between the Workshop's participants and the scholars in residence added significantly to the productivity of the meeting. The CRM once more demonstrated how its excellent facilities and professional organizational support create the perfect initial conditions for productive meetings of mathematical scientists.

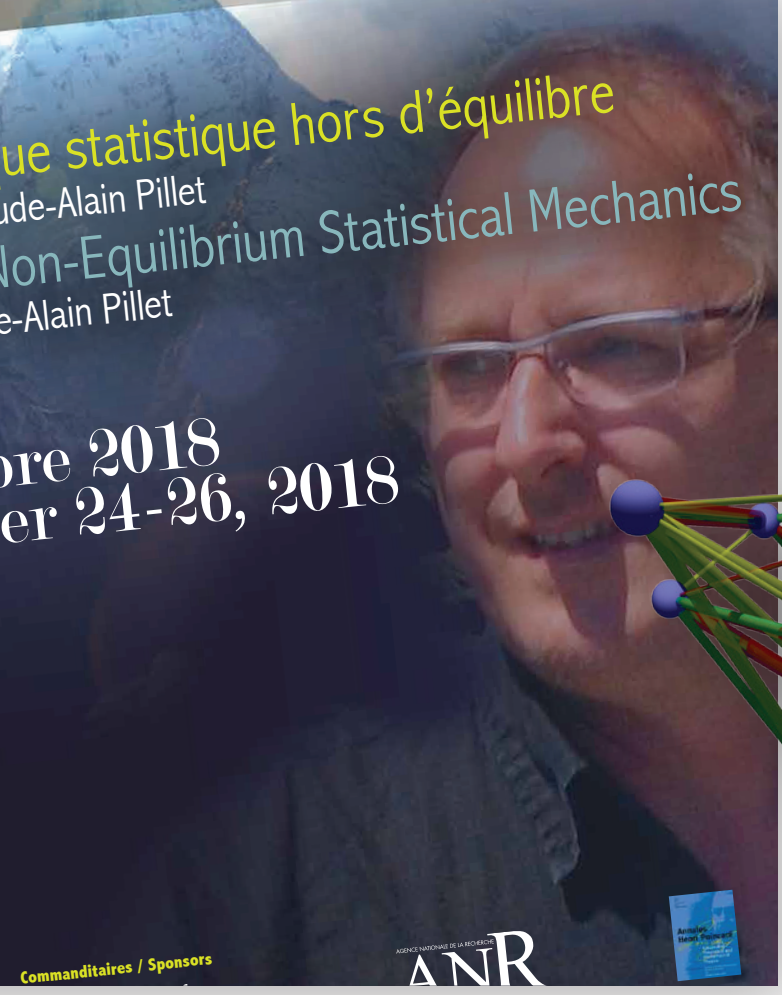
24-26 October 2018
School on Mathematics of Non-Equilibrium Statistical Mechanics, on the occasion of the 60th birthday of Claude-Alain Pillet

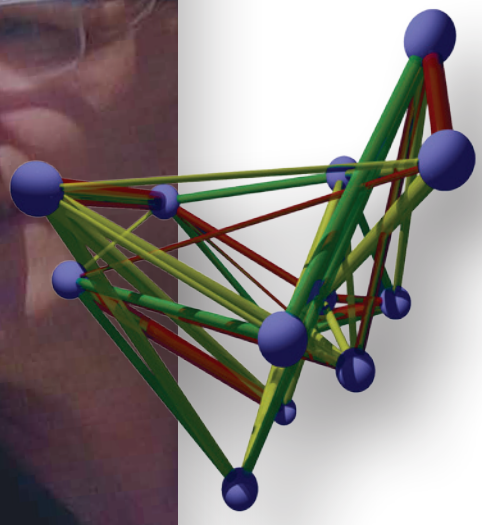
Organizers: *Jean-Marie Barbaroux (Université du Sud Toulon-Var); Horia Cornean*

(Aalborg University); Vojkan Jakšic (McGill University); Flora Koukiou (Université de Cergy-Pontoise, Saint-Martin); Armen Shirikyan (Université de Cergy-Pontoise, Saint-Martin)

The objective of this school was to expose the participants to the latest developments in the mathematical theory of non-equilibrium statistical mechanics. The lectures were pedagogical and accessible to all attendees. The school was a preliminary to the workshop "Entropic Fluctuation Relations in Mathematics and Physics".







29 October - 2 November 2018
Entropic Fluctuation Relations in Mathematics and Physics

Organizers: *Vojkan Jakšic (McGill University); Christian Maes (KU Leuven); Claude-Alain Pillet (Université du Sud Toulon-Var)*

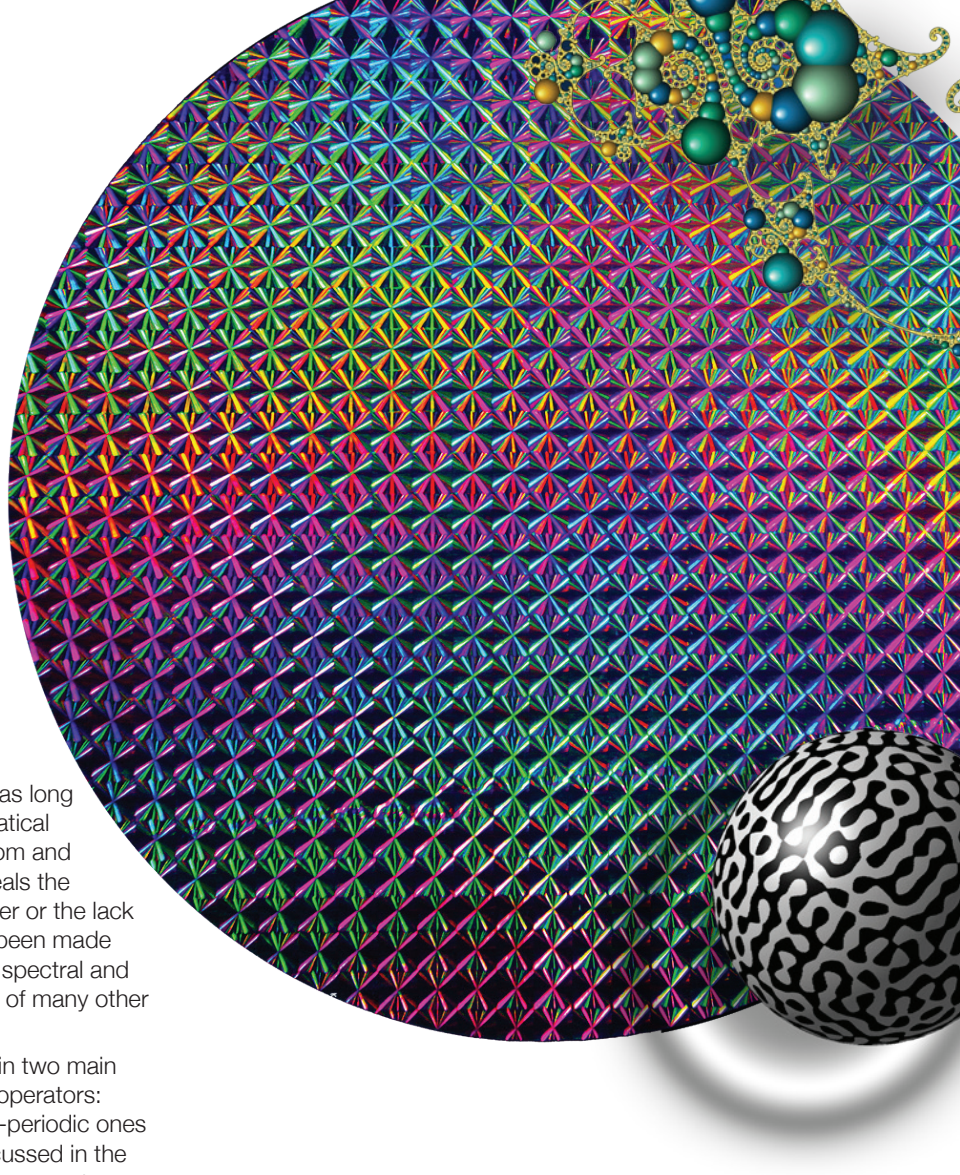
The main objective was to gather physicists and mathematicians around current topics in nonequilibrium statistical mechanics, and more specifically to have them share recent advances and discuss open problems related to the statistics of fluctuations of entropic quantities in physical systems out of thermal equilibrium. The response of the two communities was enthusiastic, and from the nearly 30 invited speakers, about half were physicists and the other half mathematicians. Physics talks ranged from experimental results and techniques to theoretical methods and to conceptual developments. They also included technological applications and numerical investigations. Some of the mathematics talks were describing results on specific models of nonequilibrium classical and quantum systems. The others were devoted to the development of analytical and probabilistic techniques adapted to the study of nonequilibrium processes.

Many of the CRM-Simons scholars and professors of the thematic semester that were in residence during the workshop were involved, either as speakers or by taking active part in the numerous informal discussions that took place during the week. The workshop was also attended by a noticeable number of younger researchers, PhD students and postdocs. In retrospect, it has achieved the original goal of tightening the links between physicists and mathematicians interested in the development of nonequilibrium statistical mechanics and will impact future collaborations between these communities.

In order to allow a large audience, composed of both PhD students and postdocs as well as experienced researchers, to attend the school in an interesting way, the format that was adopted consisted of morning lectures of two hours each by leading names in non-equilibrium statistical mechanics (D. Ruelle, J.-P. Eckmann and C. Liverani) and of one-hour lectures each in the afternoon, including a more detailed presentation of the mathematical techniques relevant to these topics.

The afternoon talks covered the study of dynamics and return to equilibrium for infinite systems of particle gases, the perturbation theory of KMS states, the presentation of self-consistent theories for many-body dynamics, etc.

This impact was important both in terms of training for non-experts, in terms of presenting relevant open questions on non-equilibrium statistical mechanics, and in emphasizing the importance of applying some of the mathematical techniques for these problems to the study of questions in related areas of science such as chemistry and biology.



12- 16 November 2018
Spectral Theory of Quasi-Periodic and Random Operators

Organizers: *Jonathan Breuer (The Hebrew University of Jerusalem); David Damanik (Rice University); Milivoje Lukic (Rice University); Simone Warzel (Technische Universität München)*

The spectral theory of complex systems has long been a topic of central interest in mathematical physics. In this context, the study of random and quasi-periodic Schrödinger operators reveals the consequences of complex long-range order or the lack thereof. While considerable progress has been made on some issues (e.g., conditions ensuring spectral and dynamical localization), our understanding of many other issues is partial at best.

The conference brought together experts in two main strands of spectral theory of Schrödinger operators: random operators on one hand and quasi-periodic ones on the other. One of the main themes discussed in the conference was that of localization. Various aspects of this phenomenon (in the random as well as in the quasi-periodic case) were discussed in talks by Mavi, Sims, Shapiro, Zhou, Jitomirskaya, and Liu. The theme of eigenvalue statistics was also a central theme in the workshop and was discussed in talks by Imbrie, Virág, Elgart, Marx, Gebert, Wang and Valkó. The natural connection to random matrices was emphasized in several talks (e.g., the ones by Valkó, Virág and Rouault). The interaction among the participants was extremely positive and fruitful, and the atmosphere was invigorating with many thought provoking discussions. We believe the interaction between the two communities has been very positive and will have a considerable influence on future research, either through collaborations or through the problems and ideas shared in the workshop.

There have been 68 participants in this workshop.

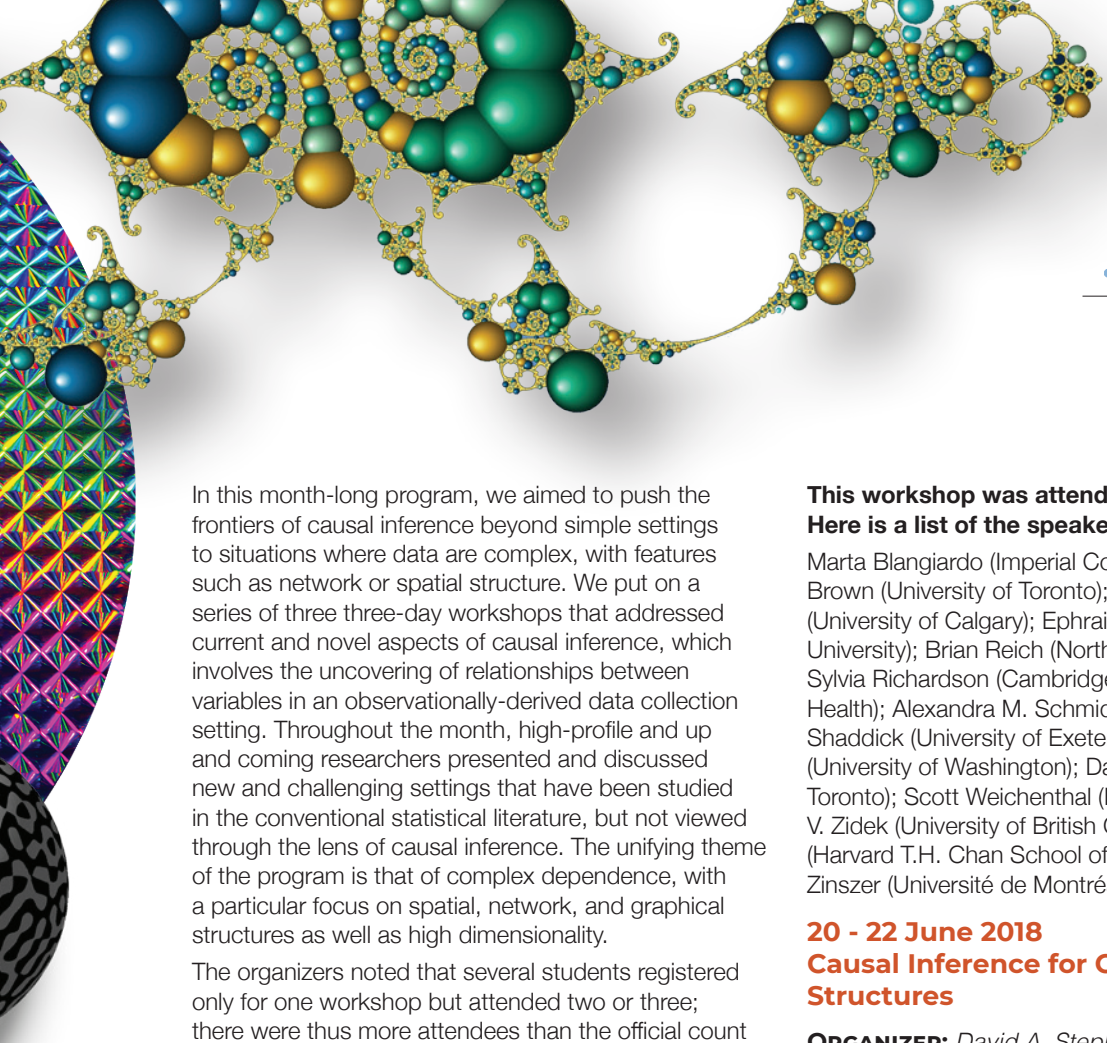
INTENSIVE MONTHLY PROGRAMS

11 June - 6 July 2018
Causal Inference in the Presence of Dependence and Network Structure

Organizers: *Erica E. M. Moodie (McGill University); Alexandra M. Schmidt (McGill University); David A. Stephens (McGill University)*

Three workshops were associated with this thematic program:

- Causal adjustment in the presence of spatial dependence (11-13 June)
- Causal inference for complex graphical structures (20-22 June)
- Discovery of causal structure in high-dimensions (25-27 June)



In this month-long program, we aimed to push the frontiers of causal inference beyond simple settings to situations where data are complex, with features such as network or spatial structure. We put on a series of three three-day workshops that addressed current and novel aspects of causal inference, which involves the uncovering of relationships between variables in an observationally-derived data collection setting. Throughout the month, high-profile and up and coming researchers presented and discussed new and challenging settings that have been studied in the conventional statistical literature, but not viewed through the lens of causal inference. The unifying theme of the program is that of complex dependence, with a particular focus on spatial, network, and graphical structures as well as high dimensionality.

The organizers noted that several students registered only for one workshop but attended two or three; there were thus more attendees than the official count suggests. The meetings also featured three Scholars in Residence: Jim Zidek, Statistics Department, University of British Columbia; Thomas Richardson, Statistics Department, University of Washington; Nicolai Meinshausen, Statistics Department, ETH Zurich.

Dr Richardson gave lectures in two of the workshops. The Scholars and several other speakers stayed beyond the workshop in which they were speaking, and several collaborations were formed. Several students from Montreal noted how the venue, the coffee breaks, and the smaller size of the workshops all provided for exciting opportunities for them to meet and mix with some of the leading researchers in the field.

11 - 13 June 2018
Causal Adjustment in the Presence of Spatial Dependence

Organizer: *David A. Stephens (McGill University)*

In many observational surveillance settings, the exposure of interest exhibits spatial dependence due to environmental, climatological or demographic factors. In such cases, standard approaches to causal adjustment need to be generalized to account for the dependence structure. Methods for dependent exposures have been developed in the case of longitudinal data, but have been overlooked for spatial data. This theme will investigate how conventional approaches to spatial epidemiology can be applied in the causal setting.

This workshop was attended by 35 participants. Here is a list of the speakers:

Marta Blangiardo (Imperial College London); Patrick Brown (University of Toronto); Robert Deardon (University of Calgary); Ephraim M. Hanks (Penn State University); Brian Reich (North Carolina State University); Sylvia Richardson (Cambridge Institute of Public Health); Alexandra M. Schmidt (McGill University); Gavin Shaddick (University of Exeter); Jonathan Wakefield (University of Washington); Daniel Simpson (University of Toronto); Scott Weichenthal (McGill University); James V. Zidek (University of British Columbia); Corwin Zigler (Harvard T.H. Chan School of Public Health); Kate Zinszer (Université de Montréal).

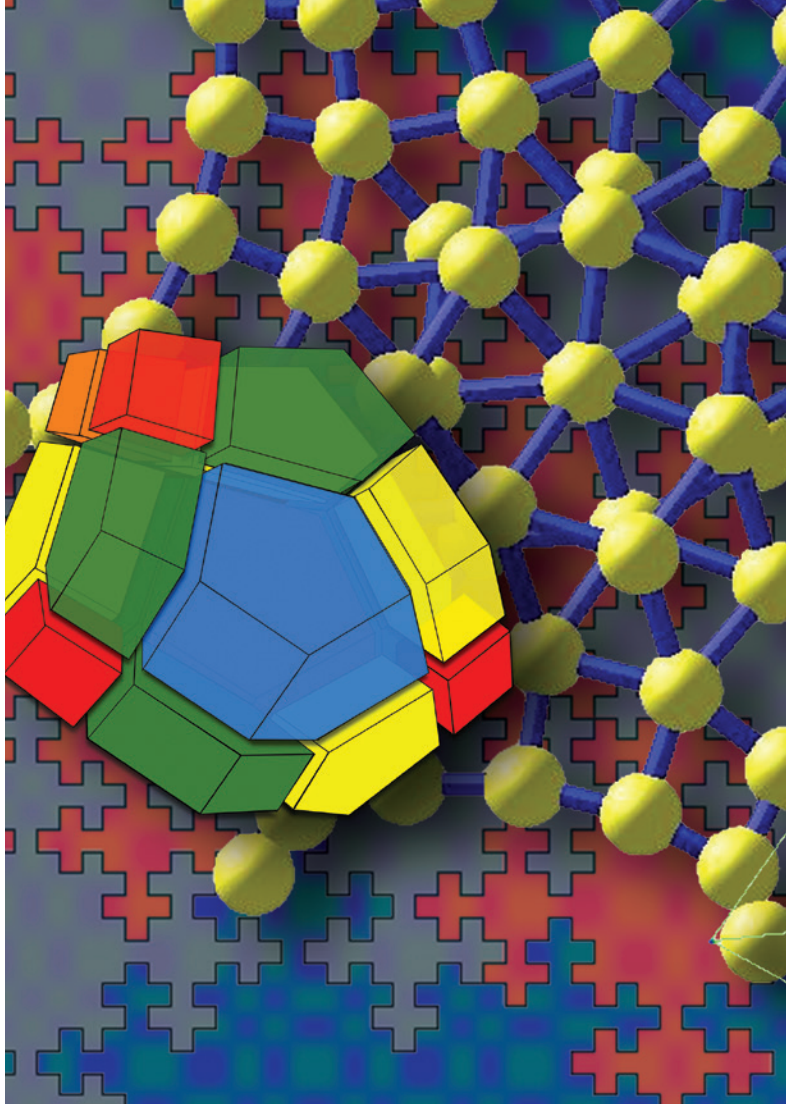
20 - 22 June 2018
Causal Inference for Complex Graphical Structures

Organizer: *David A. Stephens (McGill University)*

Causal adjustment strategies usually rely on knowledge of the (presumed) DAG structure underlying the data generation. However, the assumption that the presumed DAG itself is correct is strong, and can been relaxed to allow for graphical structures with more uncertainty about directionality to be proposed -- for example, Complete Partially Directed Acyclic Graphs (CPDAGs) allow the direction of relationships between nodes in the graph to be unknown. Such structures have thus far not been studied in great detail with respect to their implications for statistical procedures. This theme will investigate these more general structures and how they alter the practitioner's approach to causal adjustment.

There were 23 participants in this workshop. Here is a list of the speakers:

Niall M. Adams (Imperial College London); Shomoita Alam (McGill University); Ayesha Ali (University of Guelph); David Benkeser (Emory University); Marco Carone (University of Washington); Nicholas Chamandy (Lyft); Robin Evans (University of Oxford); Daniel J. Graham (Imperial College London); M. Elizabeth Halloran (University of Washington); Michael Hudgens (University of North Carolina at Chapel Hill); Thomas S. Richardson (University of Washington); Alexander Volfovsky (Duke University).



25 - 27 June 2018
Discovery of Causal Structure in High Dimensions

Organizer: *Erica E.M. Moodie (McGill University)*

Data dimensionality is becoming an increasing challenge in causal inference. For example, there is currently much interest in learning network structure from observational data for use in statistical genetics, microbiomics, social network applications etc. If a large number of potential confounders are available, the discovery of plausible DAG structures is itself a major hurdle to correct adjustment for confounding, and reliance on subject matter expertise may be unreliable. One strategy for causal structure discovery is based on the `PC algorithm' that performs sequential hypothesis testing for dependence and structure simplification and orientation. However, this algorithm is largely heuristic, and not designed for large dimensional data. This theme will investigate new approaches to causal structure discovery, with a focus on high dimensional settings and current issues in network inference.

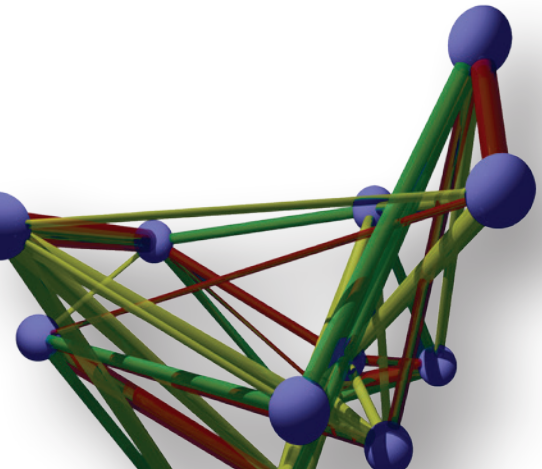
There were 31 participants in this workshop. Here is a list of the speakers:

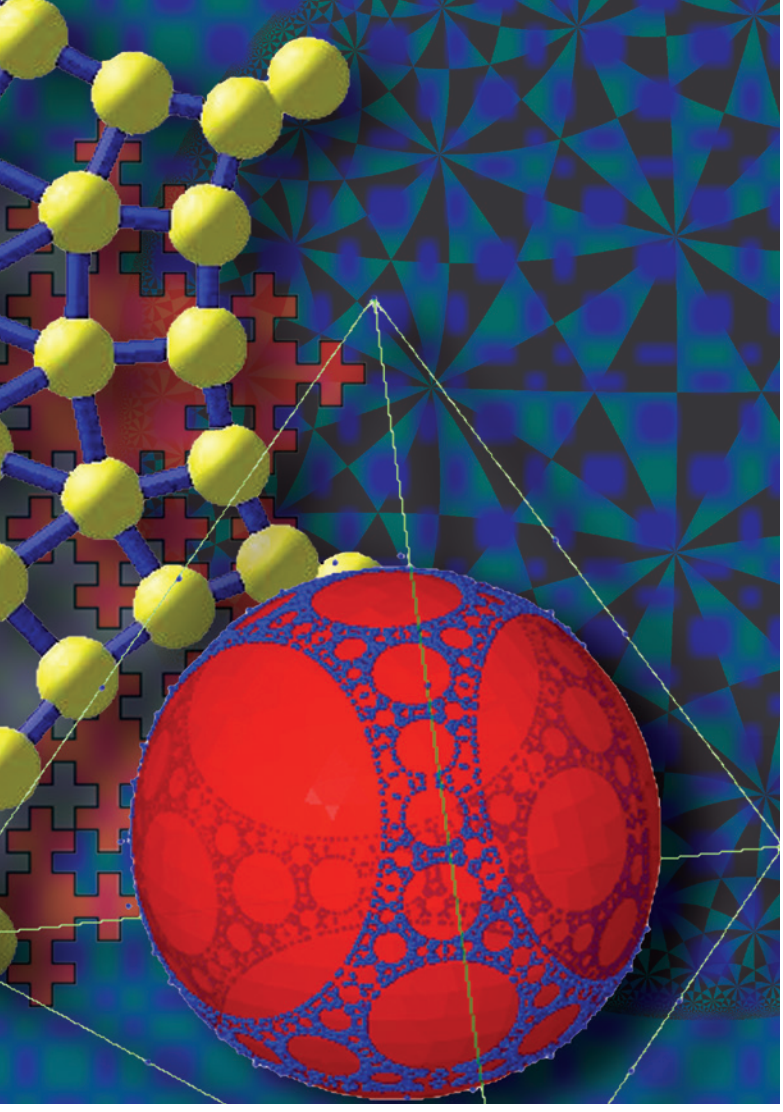
Walter Dempsey (Harvard University); Guido W. Imbens (Stanford Graduate School of Business); Eric Laber (NC State University); Nicolai Meinshausen (ETH Zürich); Yang Ning (Cornell University); Thomas S. Richardson (University of Washington); James Robins (Harvard School of Public Health); Michael Rosenblum (Johns Hopkins Bloomberg School of Public Health); Mireille Schnitzer (Université de Montréal); Peter Schulam (Johns Hopkins University); Ali Shojaie (University of Washington); Susan Shortreed (Kaiser Permanente Washington Health Research Institute); Arvid Sjölander (Karolinska Institutet); Denis Talbot (Université Laval); Stefan Wager (Stanford University); Julian Wolfson (University of Minnesota); Min-ge Xie (Rutgers University).

17 September - 14 October 2018
Algebra, Combinatorics, and Mathematical Computer Science

Organizers: *François Bergeron (UQÀM); Srecko Brlek (UQÀM); Christophe Hohlweg (UQÀM)*

The Laboratory of Combinatorics and Mathematical Informatics (LaCIM) organised a month of scientific activities around the topics that have been at the center of the concerns of the members of LaCIM since its creation: algebraic combinatorics, combinatorial representation theory; Coxeter groups theory, combinatorics of words, discrete geometry; enumerative combinatorics; mathematical computer science and their applications. These scientific activities were articulated around the presence of three renowned researchers: Mireille Bousquet-Mélou (LaBRI, CNRS and University of Bordeaux), who also held the Aisenstadt Chair during her stay, as well as Ezra Miller (Duke University) and Stéphanie van Willigenburg (UBC) who benefited from the "Simons-CRM researchers" program.





- From 17 to 22 September, Ezra Miller gave a series of three lectures entitled “From representations of quivers and posets to applied real commutative algebra”, the last of which took place at the Colloque des Sciences Mathématiques du Québec (CSMQ).
- From 24 to 28 September, an international conference entitled “Algebra and Combinatorics at the LaCIM” was held, attended by about 50 researchers and their students. The 22 speakers came from Canada, the USA, France, Italy and Australia.
- From 1 to 5 October, Mireille Bousquet-Mélou gave a series of three lectures entitled “Counting lattice walks confined to cones”, one of them taking place during the Colloque des Sciences Mathématiques du Québec (CSMQ).
- Finally, from 8 to 12 October, Stephanie van Willigenburg gave a series of three lectures on the subject of symmetric and quasi-symmetric functions.

1 - 31 March 2019

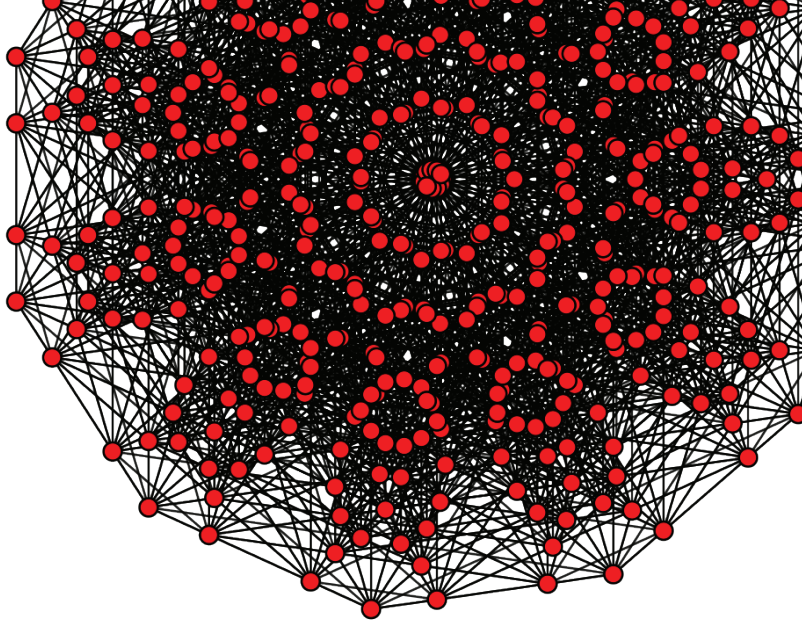
New Developments in Free Probability and Applications

Organizers: *Benoît Collins (Kyoto University); James A. Mingo (Queen’s University); Roland Speicher (Saarland University); Dan-Virgil Voiculescu (University of California at Berkeley)*

This one-month program consisted of two workshops and an intermediate two weeks with thorough introductions to some of the present developments as well as seminar talks, many of them by the junior researchers who stayed for the whole program. Since a quite big part of the audience consisted also of graduate students and junior researchers, a more thorough introduction to some of the present developments were given in the two weeks following the first workshop: a series of lectures on analytic regularity properties of non-commutative distributions and its relation with more algebraic concepts, like the free skew field; a series of lectures on traffic freeness, both on the foundations as well as its connection and use for random matrices; and an introduction to the analytic subordination description of free convolution and its ramifications for dealing with outliers and spikes in the context of random matrix models. In addition students and new researchers were given a venue to present their own work. This enabled the mentoring of the next generation of researchers in free probability.

The three Aisenstadt talks of Alice Guionnet were embedded into the general program of the workshop. Whereas her public talk gave a general idea of the connection between random matrices and free probability theory, her second talk was an introduction to the use of Dyson-Schwinger equations in this context, and the last talk opened the second workshop, by outlining the progress in some ongoing work in the context of free entropy.

The second workshop “Free Probability: the applied perspective” had its focus on more applied directions.



Many of the talks during the second workshop addressed such issues and showed this surprising arch of free probability from the abstract to the very applied: we saw three vignettes on free probability and statistics; heard about a new theory for sketching in linear regression; and learned about free probability for deep learning. After the talk various groups started to apply the new ideas to other similar problems.

The program on free probability was a big success. In particular, the attendance of many young researchers, often for the whole month or a substantial part of it, and the many lively discussions in the seminar rooms and halls of the Pavillon Aisenstadt, following the talks or signalling ongoing or new collaborations, showed clearly that the subject is still very vibrant and full of new ideas.

1 - 26 April 2019

Topological and Rigorous Computational Methods for High Dimensional Dynamics

Organizers: *Jean-Philippe Lessard (McGill University); Konstantin Mischaikow (Rutgers University); Jan Bouwe van den Berg (Vrije Universiteit Amsterdam)*

This activity was aimed at junior researchers starting in the field. It offered a rapid course on computer-assisted proofs in dynamics, starting from the foundations and reaching some of the current research developments, all the ideas related to data, computation, topology and analysis in high and infinite dimensional dynamical systems came together. The program included talks on application areas such as neurons, biological clocks, gene regulatory networks, material science, fluid dynamics and granular media. There was again plenty of time for discussion, which often continued over dinner into the night. The final week was characterized by more collaborative work between the month-long visitors, which led to progress on a variety of projects.

We list some highlights:

- several major improvements were obtained which should enable us to prove existence of 3D periodic solutions in the autonomous Navier-Stokes equations;
- seminal progress was made towards the implementation of a semi-group approach to the rigorous integration of parabolic PDEs and its application to computer-assisted proofs of existence of connecting orbits in infinite dimensional dynamical systems;
- computer-assisted proofs were obtained for bifurcations from a polygonal equilibrium in the n-body problem. This work is an essential step towards the proof of a long-standing conjecture about the existence of branches of periodic orbits connecting the Lagrange equilateral central configuration to the figure-eight choreography in the three-body problem;
- a novel setup for the infinite dimensional stable manifolds of periodic solutions of parabolic PDEs was pioneered;
- eigenvalues bounds were derived to rigorously enclose the solutions of some elliptic PDEs describing the first exit time of a stochastic ODE, with the aim of proving the occurrence of coherence resonance;
- unconventional techniques were initiated to identify local unstable manifolds near fixed points from experimental time series data of forced fluid flow using ideas from rigorous numerical computations of invariant sets and geometric data analysis;
- a probabilistic approach to inferring Conley indices in sampled dynamical systems was devised;
- new insights were obtained in formulating the optimal forcing theorem based on relative indices in strongly indefinite problems.

The lasting impact of the thematic month has several different facets. First, there is the research progress described above, which includes multiple novel connections. Many of these advances were possible only through the intense concentration of expertise during the month-long program. Second, new collaborations

and friendships were formed. Particularly for the many junior participants (supported by the CRM, the Simons foundation, and an NSF grant) being exposed to such a diversity of approaches and subjects has broadened their research paths. Community building was another important aspect: plans for follow-up activities have already been made. Overall, thanks to the generous support of the CRM, its facilities and highly competent staff, the month-long program was a complete success.

29 April - 17 May 2019

Faces of Integrability Program

Organizers: *Jacques Hurtubise (McGill University); Nicolai Reshetikhin (University of California at Berkeley); Laurent K. Williams (University of California at Berkeley)*

The theory of integrable systems, with its origins in symmetries, has intricate ties to a wide variety of areas of mathematics. Themes covered include the role of cluster algebras and cluster varieties in the description of moduli spaces, the links between integrable systems and representation theory appearing in such areas as quantum groups and quantization of moduli spaces, and the fascinating interfaces of probability theory, combinatorics and integrable systems appearing in several processes linked to statistical mechanical models.

The speakers during the conference covered a wide variety of aspects of the theory, ranging from the strongly geometrical to the quite algebraic, from continuous systems to discrete ones, from classical to quantum, and from deterministic to probabilistic. The first day had a strong geometrical bent, with Boris Khesin discussing variants of the Pentagram map, Simonetta Abenda the passage from finite-gap KP solutions to solitons, Vladimir Roubtsov the Calogero-Painlevé systems, and Marco Bertola the symplectic nature of the monodromy map for the Riemann sphere. The day was punctuated by an algebraic interlude, with Rinat Kedem discussing the operators associated with Q-systems.

8 - 29 May 2019

Data Assimilation: Theory, Algorithms, and Applications

Organizers: *Antony R. Humphries (McGill University); Sebastian Reich (Universität Potsdam); Andrew M. Stuart (California Institute of Technology)*

The seamless integration of large data sets into computational models provides one of the central challenges for the mathematical sciences of the 21st century. When the computational model is based on dynamical systems and the data is time ordered, the process of combining data and models is called data assimilation.

Historically, the field has been primarily developed by practitioners within the geophysical sciences; however, it has enormous potential in many more subject areas. The month-long thematic activity on Data Assimilation, which started with this training school, is aimed at developing the underpinning mathematical theory of data assimilation, the process of combining data with dynamical systems to learn hidden states and unknown parameters. The activities are guided and informed by applications coming from the physical, biomedical, social and cognitive sciences. Methodologies based around particle filtering, ensemble Kalman filtering, optimization and Bayesian inverse problems underpin the program. Workshops on applications of data assimilation and on machine learning and inverse problems are the focus of the activities.

Given the objectives of the one-month CRM program, we chose to organise a large-scale training school covering not only data assimilation, but also the inverse problems and applications of both methods in machine learning.

The lectures were given by two of the thematic activity organisers Sebastian Reich (Potsdam) and Andew Stuart (Caltech), who were joined by Eldad Haber (UBC). Reich overviewed the subject of data assimilation, Stuart covered inverse problems, illustrating ideas with discussions of unsupervised and semi-supervised learning, and Haber overviewed supervised learning. Haber's lectures used python-based software to illustrate concepts and freely available software was made accessible to the students.

1 - 30 June 2019

Homological Algebra, Microlocal Analysis and Symplectic Geometry

Organizers: *Emmanuel Giroux (Unité Mixte Internationale CNRS-CRM); Stéphane Guillermou (Université Grenoble Alpes)*

The program welcomed a total of 70 participants and was attended on a daily basis by an average of 40 people, half of them being internationally recognised experts and half being students and young postdocs who were able to attend 75 hours of lectures.

The purpose of this scientific program was to present and discuss recent developments in applications of the microlocal theory of sheaves to symplectic geometry and related topics.

Week 1, 3-7 June: Introductory lectures, 3 lectures of 1.5 hours per day.

- "Microlocal Theory of Sheaves" by Stéphane Guillermou (Grenoble Alpes) (7h30 in total);
- "Introduction to Infinity Categories" by André Joyal (UQAM)(6h);
- "Generating Functions, Old and New" by Sylvain Courte (Grenoble Alpes) (7h30).

Weeks 2 and 3, from 10 to 14 and 17 to 21 June: advanced courses at the rate of 2 classes of 1h30 per day up to 19 June (in order to leave ample time for discussions) and 3 classes on 20 and 21 June.

- "Arboreal Singularities and Symplectic Invariants of Weinstein Domains" by Daniel Álvarez-Gavela (Institute for Advanced Study), David Nadler (UC Berkeley) and Laura Starkston (UC Davis) (9h).
- "Sheaf Quantization of Lagrangians and Floer Cohomology" by Claude Viterbo (ENS Paris) (6h).
- "Microlocal Category" by Dmitry Tamarkin (Northwestern) (7h30).
- "Liouville Sectors and Wrapped Floer Theory" by Sheel Ganatra (Southern California), John Pardon (Princeton) and Vivek Shende (UC Berkeley) (7h30).
- "Sheaf Quantization of the Exact Symplectic Category" by David Nadler (UC Berkeley) and Vivek Shende (UC Berkeley) (3h).

Week 4, 24-28 June: conference with 5 one-hour presentations per day until Thursday (including an open question session).

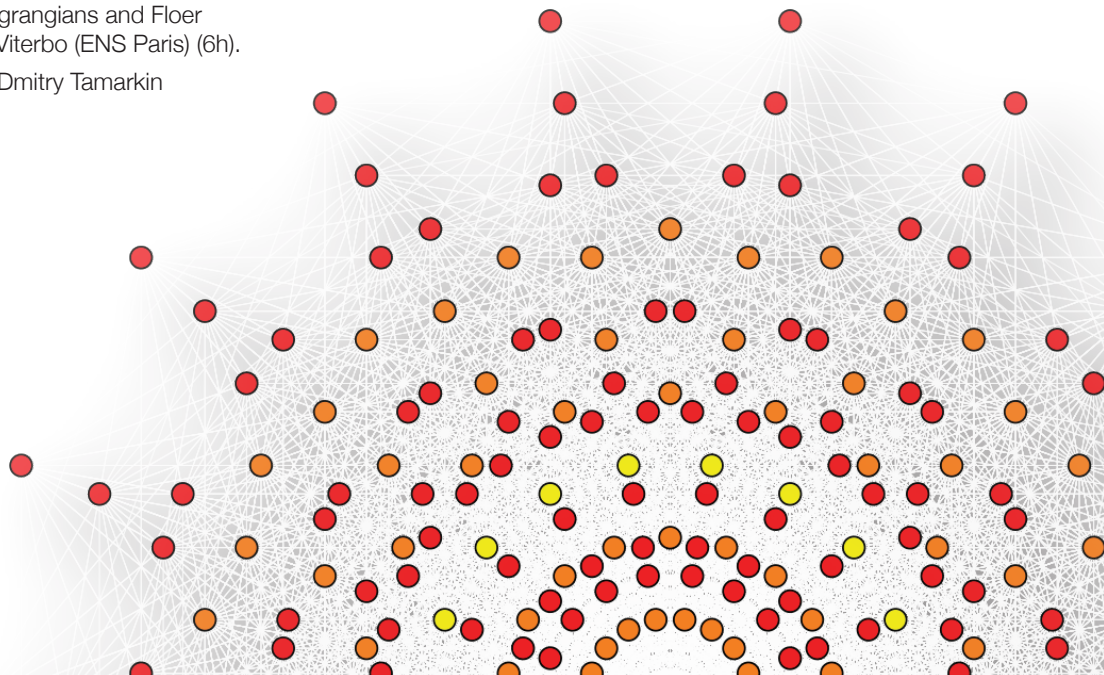
This program has allowed the participants to thoroughly discuss the most recent and innovative results related to homological and homotopic methods in symplectic geometry. The funding was ensured by the CRM, the FRQ (through the UMI mirroring scheme), the Simons Foundation (with 5 CRM Simons grants), the ANR (Microlocal project) and the UMI-CRM.

1 - 31 July 2019

Expansions, Lie Algebras and Invariants

Organizers: *Anton Alekseev (Université de Genève); Dror Bar-Natan (University of Toronto); Roland van der Veen (Leiden University)*

The workshop was attended by a group of experts who work on "expansions" and a number of experts who work on "invariants". "Expansions" are solutions of a certain type of intricate equations within graded spaces often associated with free Lie algebras; they include Drinfel'd associators, solutions of the Kashiwara-Vergne equations, solutions of various deformation quantization problems, and more. By "invariants" we



refer to quantum-algebra-inspired invariants of various objects within low-dimensional topology; these are often associated with various semi-simple Lie algebras. The two subjects were born together in the early days of quantum group theory, but have to a large extent evolved separately.

In short, on the first week Bar-Natan, Alekseev, Naef, van der Veen, and Schneps gave long introductory lectures on foundational topics for the field, with titles "Expansions, Lie algebras and Invariants", "Goldman brackets, Turaev cobrackets and formality", "Formality of string topology in dimensions ≥ 2 and Kashiwara-Vergne", "Universal invariants and quasi-triangular Hopf algebras and Polynomial time knot invariants", and "The mould theory approach to elliptic multizetas and Kashiwara-Vergne".

The second week was conference-style, with a total of 14 lectures. It was aimed to give each speaker at least 90 minutes to allow each lecture to provide an in-depth development of a research topic.

The rest of the month, another two and a half weeks, was "workshop style", with a lot of free time for the participants to interact, exchange ideas, and make research progress. Yet almost every day we had at least one participant give an even longer lecture or a pair of lectures, at an even greater depth.

In total, we had 27 participants.
Here is a list of the speakers:

Dror Bar-Natan (Toronto), Anton Alekseev (Geneva), Florian Naef (MIT), Roland van der Veen (Leiden, now Groningen)., Leila Schneps (Paris), Gwenael Massuyeau (Bourgogne), Adam Sikora (Buffalo), Tetsuya Ito (Kyoto), Dylan Thurston (Bloomington), Ulf Kuehn (Hamburg), Delphine Moussard (Marseille), François Costantino (Toulouse), Marcy Robertson (Melbourne), Pavol Severa (Geneva), Yusuke Kuno (Tokyo), Sakie Suzuki (Tokyo), Zsuzsanna Dancso (Sydney), Travis Ens (Toronto), Thang Le (Atlanta), Nariya Kawazumi (Tokyo), Jun Murakami (Tokyo), Brant Pym (Montreal), Hidekazu Furusho (Nagoya), and Benjamin Enriquez (Strasbourg).

Some of our participants were in the early stages of their careers, as graduate students or post-docs (including Travis Ens, Quentin Faes, Jesse Frohlich, Delphine Moussard, Florian Naef, and Nancy Scherich). We believe we made a great and lasting contribution to the professional development of these people.

1 - 31 August 2019

Quiver Varieties and Representation Theory

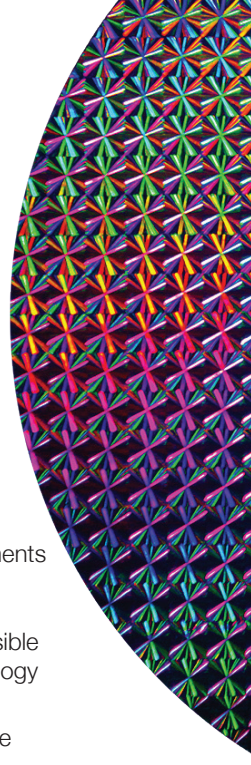
Organizers: *Joel Kamnitzer (University of Toronto); Hugh Thomas (UQÀM)*

The representation theory of quivers (and related preprojective algebras) has been studied by researchers from algebra, while the geometry of quiver varieties has been studied by researchers in geometric representation theory. This thematic activity brought together members of two communities: algebra and geometric representation theory. This thematic activity was an opportunity to present the respective progress of these communities and to establish research partnerships.

Topics covered included quantization of quiver varieties, constructions of Coulomb branches using quiver varieties, tilting theory for preprojective algebras and categorization of clustered algebras.The activity bring together members of these two communities to exchange recent progress and to stimulate further research and collaboration.

Among other topics, we discussed quantization of quiver varieties, Coulomb branch constructions using quiver varieties, tilting theory for preprojective algebras, and categorification of cluster algebras.

- **August 5-9:** Focus week on cluster algebras and quiver representations, with a mini-course by Pierre-Guy Plamondon.
- **August 12-16:** Workshop on quiver varieties and representation theory.
- **August 19-23:** Focus week on quiver varieties, with mini-courses by Michael Finkelberg and Hiraku Nakajima.



Mini-courses and lectures - Cluster algebra (August 5-9)

Categorification of cluster algebras via 2-Calabi-Yau categories has proved to be a powerful technique for understanding cluster algebras and proving important structural results about them.

Workshop - Quiver varieties and representation theory (August 12-16)

The workshop will bring together experts in a variety of topics at the intersection of geometric and algebraic approaches to representation theory, organized around the theme of quivers. Topics include a selection of the following: cohomological Hall algebra, cluster algebras (bases; duality; categorification), moduli of sheaves on surfaces, affine Grassmannian slices, degenerate flag varieties, symplectic duality, tilting theory.

Mini-courses and lectures - Quiver variety (August 19-23)

An important recent development in geometric representation theory (with close connections to quiver varieties) is the mathematical approach to Coulomb branches, developed by Alexander Braverman, Michael Finkelberg, and Hiraku Nakajima. During this focus week, Finkelberg and Nakajima gave mini-courses on specific aspects of this theory, namely Shifted quantum affine algebras and Cherkis bow varieties. A number of complementary lectures by other visitors have also been scheduled.

26 August - 20 September 2019

Low-Dimensional Topology

Organizers: *Steven Patrick Boyer (UQÀM); Liam Watson (University of British Columbia)*

This is an area of research that includes geometric topology in dimensions 3 and 4, knot theory, and geometric group theory (to name a few) while drawing on techniques from symplectic topology and gauge theory towards the resolution of long-standing problems. While many new connections are being established, the field as a whole is at an exciting crossroads; some of the greatest open problems have been resolved – such as the geometrization of 3-manifolds due to Perelman and the positive resolution of the virtual Haken conjecture due to Agol and Wise. These works have opened new vistas of questions and conjectures for further study.

Ciprian Manolescu served as distinguished researcher-in-residence for the thematic month. Manolescu's recent and highly celebrated disproof of the triangulation conjecture [Pin(2)-equivariant Seiberg–Witten Floer homology and the triangulation conjecture, Journal of the American Mathematical Society, 2016] is emblematic of the current activity in low-dimensions described above.

The aim of this focused month, which will coalesce around the work of the program's researcher-in-residence, will be to take stock of current developments in the field and highlight the many exciting new directions present in this area of research. As such, the program will endeavor to include and be accessible to early career researchers in low-dimensional topology and related fields.

This thematic program took place as follows and the focus varied week by week over the four weeks of activities:

Week 1: ISM Discovery School Progress in Low Dimensions

It was based around recent developments in low-dimensional topology, centered on the work of Ciprian Manolescu. The particular focus was on new developments in Heegaard-Floer homology and gauge theory, and the developments growing out of Manolescu's celebrated disproof of the triangulation conjecture. There were 21 young mathematicians, mostly doctorals students, registered for the school.

Week 2: Aisenstadt Chair Lectures delivered by Ciprian Manolescu of Stanford University.

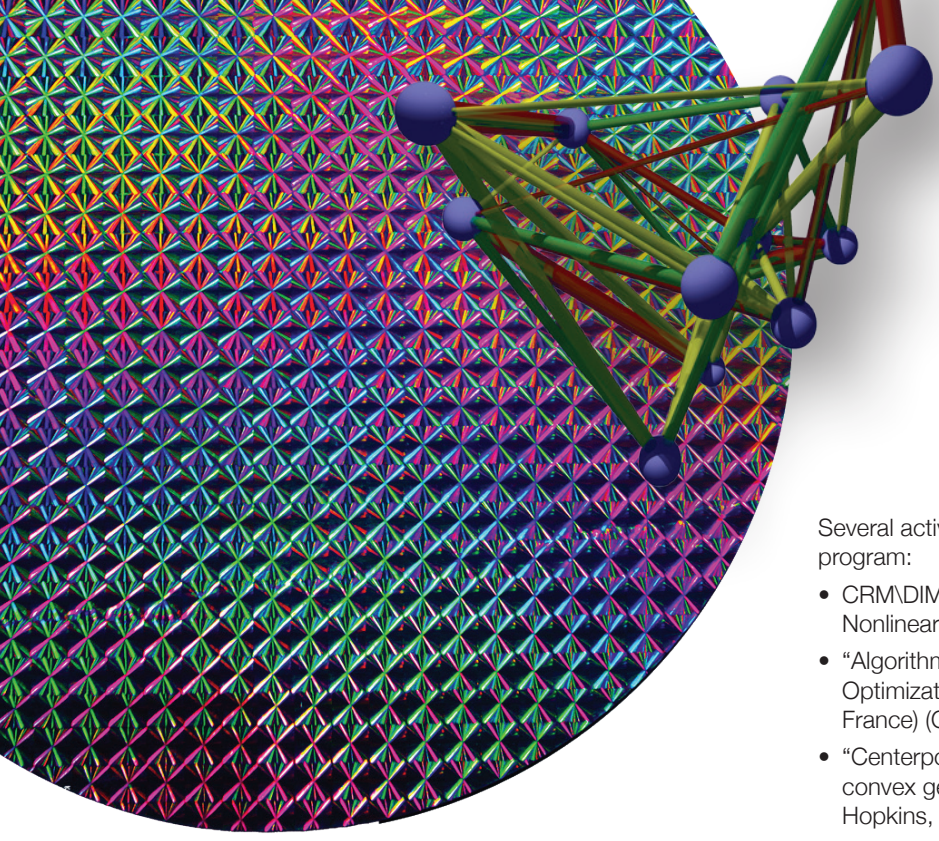
Week 3: CIRGET Hot topics Lectures delivered by Lisa Piccirillo of Brandeis University and MIT.

It was cente red on a series of three lectures delivered by Lisa Picirillo, currently an NSF postdoctoral fellow at Brandeis University and a CLE Moore Instructor at MIT. Though only recently having obtained her PhD, Poccirillo has already made groundbreaking contributions to the field. In particular, her preprint "The Conway knot is not slice" solved a problem about 4-dimensional topology, which had confounded experts for many years. This work hinged on an ingenious analysis of a certain 4-manifold construction known as a knot trace (followed by a clever, and crucial, appeal to Khovanov invariants), and it is knot traces which formed the central theme of her three lectures.

Week 4: Workshop on codimension 1 phenomena in low-dimensional topology

This program was dedicated to a series of ten morning talks spread out over five days loosely connected, though not exclusively, under the theme of codimension one phenomena in low-dimensional topology. Afternoons were devoted to research interactions between the participants.

There were also a large number of shorter-term visitors who participated in one or more of the weekly activities. These included some 20 young mathematicians registered in the Discovery School and over thirteen established researchers involved in weeks 2 through 4. The latter gave hour-long seminar talks spread out over the three weeks.



1 - 31 October 2019

Mixed Integer Nonlinear Programming: Theory and Computation

Organizers: *Andrea Lodi (Polytechnique Montréal); Bruce Shepherd (UBC)*

Mixed-integer nonlinear programming (MINLP) is concerned with finding optimal solutions to mathematical-optimization models that combine both discrete and (continuous) nonlinear elements. Models with this flavor arise in important applications in many domains, notably chemical engineering, energy, and transportation. Moreover, the well-developed frameworks for discrete and continuous optimization are not sufficient in themselves to attack this broad class of models. The underlying mathematical complexity is not as well understood due to the combination of how non-convexities arise from both the discrete and nonlinear elements. In particular, there remain theoretical, algorithmic and computational challenges before MINLP can enjoy a success similar to, say, smooth optimization or integer linear programming. These research challenges, together with the potential for remarkable impact, make MINLP arguably the most exciting new frontier in mathematical optimization. MINLP has caught the attention of all major optimization societies which have fostered work in this area. MINLP has also established new and significant links between industry and academia.

Several activities were carried out under this thematic program:

- CRM\DIMACS Workshop on “Mixed-Integer Nonlinear Programming” (5-10 October)
- “Algorithmic Configuration By Learning And Optimization”, Gabriele Iommazzo (Polytechnique, France) (October 15)
- “Centerpoints: A link between optimization and convex geometry”, Dr. Amitabh Basu (Johns Hopkins, USA) (17 october)
- “Connecting optimization with spectral analysis of tri-diagonal Hankel matrices”, Dr. Jean-Bernard Lasserre (CNRS, France) (22 october)

1 - 30 November 2019

Mathematical Physiology – Better Health through Mathematics

Organizers: *Jacques Bélair (Université de Montréal); John Milton (The Claremont Colleges); Fahima Nekka (Université de Montréal)*

The activities around this theme took the form of a conference and three workshops of three days each spread over three weeks, developed around the following sub-themes: Dynamic Disease: from the board to the bedside; Dynamic Disease and Mobile Health: chronic diseases; and Dynamic Disease and Mobile Health: rare events. This was an opportunity to present a review of the work on Dynamic Diseases over the last twenty-five years, since the NATO workshop (organised by the CRM) held at Mont-Tremblant on this theme in February 1994. The conference also aimed to take stock of the current state of the use of nonlinear dynamics in physiological modeling, the extent to which these models influence, directly or indirectly, clinical practice, and, in a contemporary perspective, the integration of high throughput physiological data collected by wearable monitors (IPhone, FitBit, Garmin, Apple Watch, etc.).

A specific objective was to promote interactions between the " traditional " mathematicians of the academic community and mathematicians working in the biotechnology industries. A particular emphasis was laid on the involvement and collaboration with computer scientists who develop applications for patients and clinicians: this objective of diverse participation was achieved.

There were 43 speakers from nine countries, including 15 from industry and clinical settings. In this respect, two presentations were of particular note. Firstly, Michael Kabay from Norwich University highlighted the many potential pitfalls in handling patient clinical records, and the need for strict adherence to security protocols to ensure privacy. And Edward Cox of dThera outlined, from an industry perspective, the enormous potential of wearable monitors for incorporating data into highly detailed and updated digital clinical records at very high rates, and the no less significant potential for jobs in designing and programming the use of this data.

All presenters have been invited to contribute a paper to the special issue of Chaos: An Interdisciplinary Journal of Nonlinear Science (surely one of the three or four best journals on nonlinear dynamics) entitled "Dynamic Diseases: A Translational Perspective". These reviews will provide a "state-of-the-art" portrait of the field, measuring how far we have come in the last quarter century and presenting the most promising avenues for future developments.

This workshop was financially supported by the Faculty of Pharmacy of the University of Montreal, the Society for Mathematical Biology (SMB) and the Simons Foundation (John Milton was Simon's-CRM's Professor).

OTHER ACTIVITIES AND EVENTS

2 - 6 July 2018

A Celebration of CICMA's Postdoctoral Program

Organizers: *Henri Darmon (McGill University); Andrew Granville (Université de Montréal)*

Since its inception in the late 1980's, CICMA's postdoctoral program has been a resounding success story, with close to 85 postdoctoral fellows supervised over the past 30 years, the vast majority (over 90%) of whom have pursued successful academic careers of their own after their stays in Montreal.

The workshop aimed to bring together all the CRM-ISM postdoctoral fellows who have worked in the CICMA laboratory over the last 30 years or so. Out of the roughly 90 who were invited, about 45 were able to attend, which along with local and other participants, made for a large and lively group of attendees.

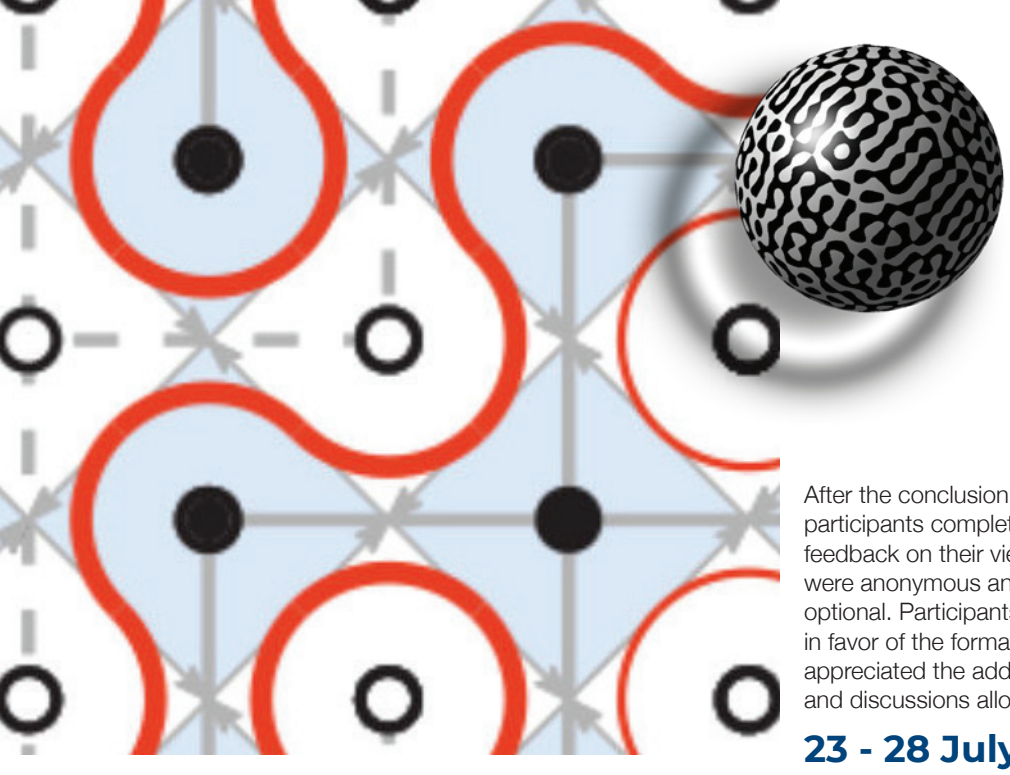
Many of our former postdocs have maintained close ties with CICMA, contributing to its success by sending their students to Montreal and, in some cases, through continued exchanges and collaborations with permanent CICMA members.

The workshop offered an opportunity to strengthen these scientific ties and to celebrate our former postdocs' achievements and contributions to the scientific life of the number theory group.

The scientific program was of an exceptionally high quality and in this sense it greatly benefitted our students and current post-doctoral fellows.

Because the event aimed to celebrate a postdoctoral program rather than focussing on a specific research direction, and because the number theory group in Montreal has traditionally been far-ranging with broad interests in both the arithmetic and analytic aspects of the subject, the scientific theme of the conference was intentionally left more diffuse, with lectures of an arithmetic and analytic nature deliberately interspersed, encouraging nontechnical lectures aimed at large segments of the number theory community.

This workshop was attended by around 94 participants.



9 - 20 July 2018

Montreal Summer Workshop on Challenges in Probability and Mathematical Physics

Organizers: *Louigi Addario-Berry (McGill); Omer Angel (UBC), Alexander Fribergh (University of Montreal)*

The aim of the workshop was to create an environment similar to a short thematic semester. There was a light schedule of talks, leaving a lot of free time to encourage collaborations between participants and to promote discussions between members of different subfields in probability theory.

The workshop was a great success. The light schedule had the intended aim of fostering discussion and collaboration, including both continuation of prior collaborations and initiation of new ones. Although there were no talks in the afternoons, participants were present and engaged. The talks were excellent, and speakers took the injunction to make their talks expository and to present accessible open problems seriously.

There have been multiple open problem sessions during the two weeks of the workshop. Initially only two were planned, but more were added to accommodate all participants who wanted to present problems. The lecture notes document also contains notes of all problems presented. Between the open problem sessions and the conjectures and open questions posed during the talks, there are a total of 45 open problems and conjectures presented within the document.

After the conclusion of the workshop, we requested that participants complete a short questionnaire, giving us feedback on their views of the workshop. Responses were anonymous and responses to all questions were optional. Participants were overwhelmingly (over 90%) in favor of the format of the workshop, and in particular appreciated the additional time for informal interaction and discussions allowed by the light schedule of talks.

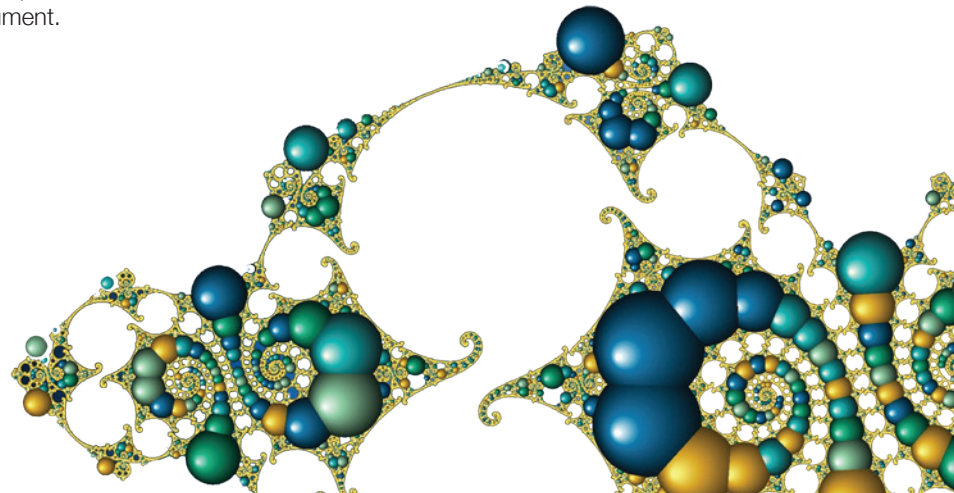
23 - 28 July 2018

XIX International Congress on Mathematical Physics (ICMP 2018)

Local organizing committee: *Michael Aizenman (Princeton); Sven Bachmann (Vancouver); Lia Bronsard (McMaster); Joel Feldman (UBC); Evans Harrell (Atlanta); Jacques Hurtubise (McGill); Dmitry Jakobson (Mcgill);Vojkan Jaksic (McGill, Convenor of the Congress); Svetlana Jitomirskaya (UC Irvine); Jeremy Quastel (Toronto)*

Following a tradition started in London in 2000, the ICMP 2018 was preceded by the Young Researchers Symposium (YRS) (July 20 and 21). Seven satellite meetings have been organized in Banff, Toronto, Montreal, and Perimeter Institute either a week before or a week after the ICMP 2018.

The ICMP and YRS were attended by 594 registered participants, out of which 121 were from Canada. The organization of the ICMP followed the traditional route, with sixteen plenary speakers and twelve topical sessions. Each topical session had six speakers, selected by two organizers, who themselves were selected by the International Scientific Committee of the ICMP (Luc Vinet, Director of the CRM, served on this committee). In addition, ten prize lectures were presented at the ICMP.

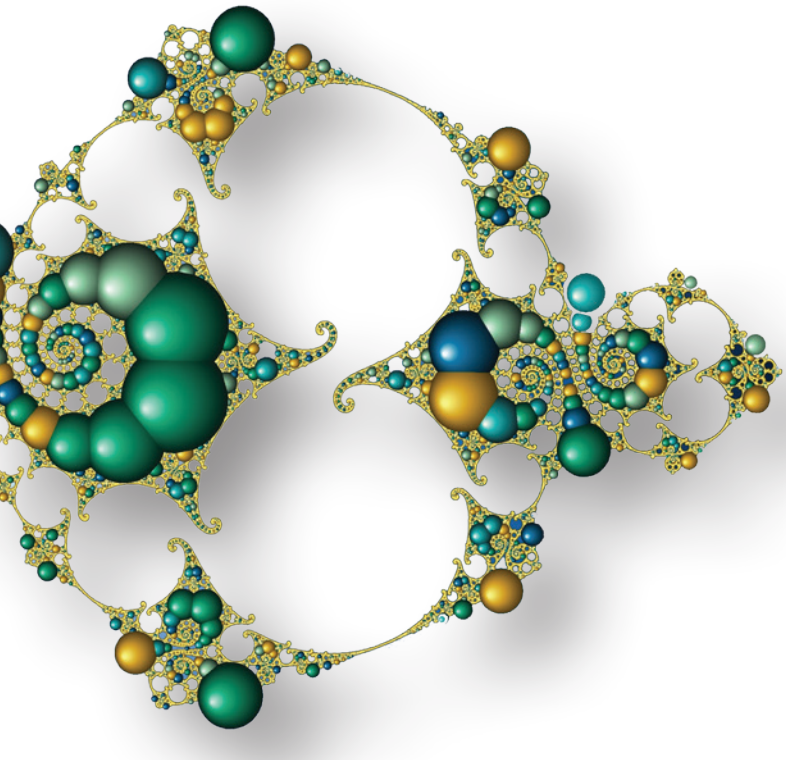


One novelty of the ICMP 2018 were two highly successful public lectures. The first was given by Rainer Weiss (MIT, Nobel Prize in Physics 2017) on Gravitational Wave Astronomy and Ligo's experimental discovery of gravitational waves. The second one was given by Elliott Lieb (Princeton University) on the topic of entropy. Many members of Montreal's scientific community attended these two lectures.

Another novel aspect of the ICMP 2018 was a large number of contributed talks (119), which were given in ten parallel evening sessions on July 24 and 27. Combined with YRS, where 66 talks were given by junior participants, the total number, variety, and quality of contributed talks significantly added to the success of the ICMP.

The organizational aspects of the ICMP were very successfully handled by the Canadian Mathematical Society.

The ICMP 2018 was a considerable international success. This success has reflected very positively on Montreal's and Canada's mathematical physics community, the CMS organizational capacities, and the entire Canada Mathematical Institutes system (these three institutes were major sponsors of the ICMP and its satellites).



3 - 7 September 2019

Workshop on New Trends in Polynomial Differential Systems

Organizers: *Jaume Llibre (Universitat Autònoma de Barcelona); Dana Schlomiuk (University of Montreal)*

This workshop focused on new developments on polynomial vector fields, involving algebraic invariant theory, construction of algorithms for effective computations, integrability problems, Hilbert's 16th problem,... and to facilitate the exchange and stimulate new research in this area.

In what follows we describe the main topics discussed in the workshop:

- The algebraic invariant theory of polynomial differential equations has had an important impact in solving some global problems such as the geometric classification of the global configurations of singularities in quadratic vector fields; global classification of some families of quadratic vector fields defined by algebraic-geometric properties; Time-reversibility and its connection to polynomial invariants of a group of transformation was discussed in the talk of V. Romanovski.
- Studies on the singularities of ordinary differential systems.
- Proofs of integrability of polynomial vector fields by algebraic-geometric methods.
- Algorithms for studying the dynamics of the polynomial vector fields: numerical algorithms.
- Recent developments on the problem of the center (also some related questions) and the study of the period function.
- Geometry of polynomial vector fields.

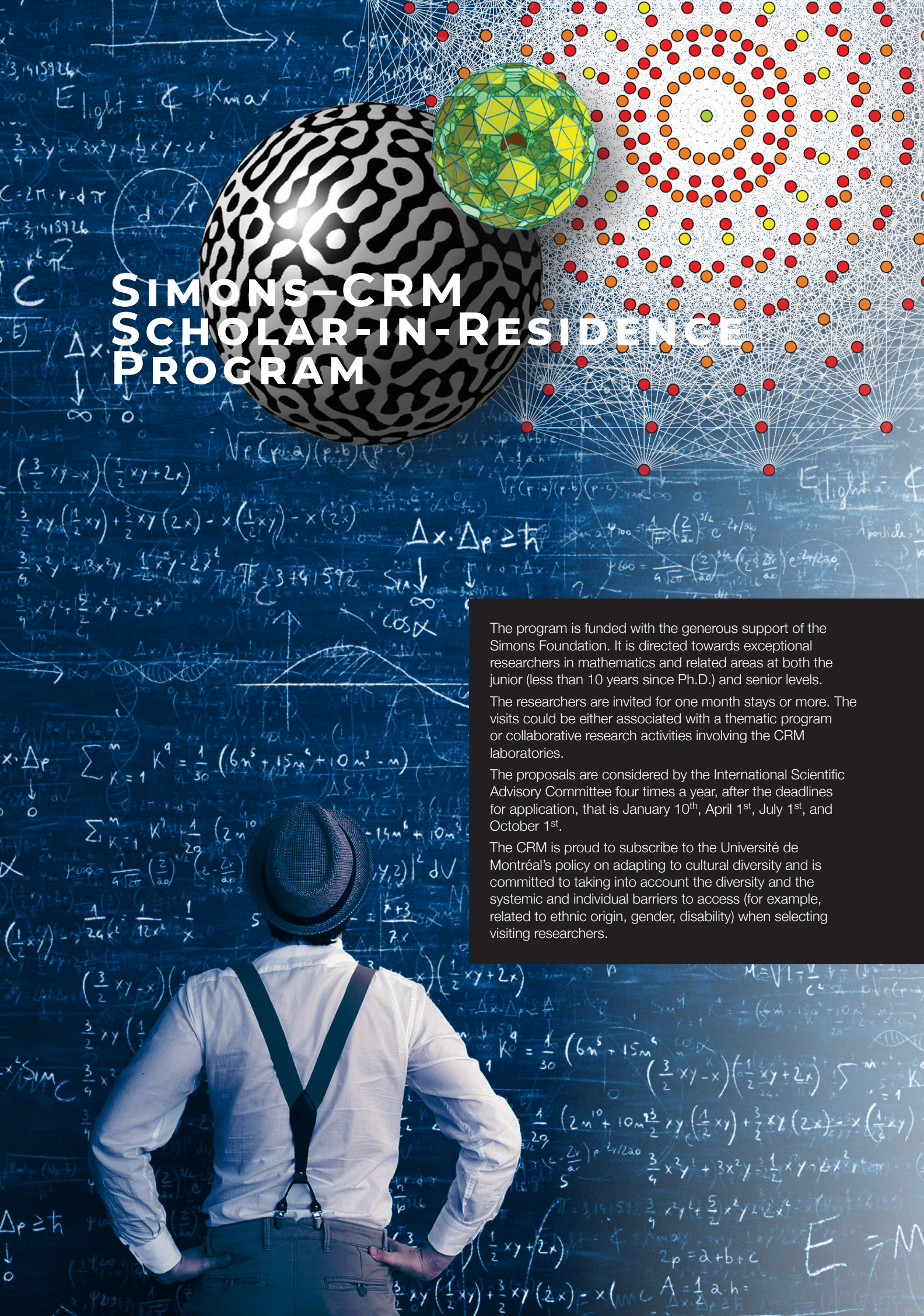
- Around the Hilbert 16th problem and the limit cycles of the polynomial vector fields. An interesting development is a novel attempt to solve Hilbert's 16th problem by using variational methods and Morse inequalities, explained in the talk of P. Pedregal on his joint work with J. Llibre.
- Singular perturbations and slow-fast systems: from a numerical point of view by H. Osinga; and for piecewise linear differential systems by A. Teruel.
- Applications of the polynomial vector fields.
- Global bifurcation of some classes of vector fields on 2-dimensional spheres.
- Complex methods and complex polynomial and rational vector fields.

The workshop was attended by 37 participants and 29 presenters.

17 November 2019

Closing conference: "Adding numbers and shuffling card"

To close the 50th anniversary celebrations, and as part of the MRC's Grand Public Lectures, the CRM organized a closing lecture by welcoming the great mathematician Persi Diaconis, winner of the MacArthur Prize twice and of the Rollo Davidson and Van Wijngaarden Awards. Persi Diaconis delivered his lecture: "Adding numbers and shuffling cards" in the attendance of a number of distinguished guests who gave the closing speeches of the 50th CRM.



Simons–CRM Scholar-in-Residence Program

The program is funded with the generous support of the Simons Foundation. It is directed towards exceptional researchers in mathematics and related areas at both the junior (less than 10 years since Ph.D.) and senior levels.

The researchers are invited for one month stays or more. The visits could be either associated with a thematic program or collaborative research activities involving the CRM laboratories.

The proposals are considered by the International Scientific Advisory Committee four times a year, after the deadlines for application, that is January 10th, April 1st, July 1st, and October 1st.

The CRM is proud to subscribe to the Université de Montréal's policy on adapting to cultural diversity and is committed to taking into account the diversity and the systemic and individual barriers to access (for example, related to ethnic origin, gender, disability) when selecting visiting researchers.

Scholars

We are proud to present the winners of the Simons - CRM researcher awards present in Montreal, in alphabetical order. The professors and scholars may be associated with a thematic program or with CRM laboratories.

Simons-CRM Visitors

Alekseev, Anton
Université de Genève

Álvarez-Gavela, Daniel
Institute for Advanced Study

Andreatta, Fabrizio
Universita Statale di Milano

Arizmendi Echegaray, Octavio
Centro de Investigación en Matemáticas

Bahns, Dorothea
Georg-August-Universität Göttingen

Bahuaud, Eric
Seattle University

Bar-Natan, Dror
University of Toronto

Basu, Amitabh
Johns Hopkins University

Belinschi, Serban Teodor
Université Paul Sabatier

Biswas, Indranil
Tata Institute of Fundamental Research

Brandenbursky, Michael
Ben Gurion University of the Negev

Breden, Maxime
ENS Cachan

Calleja, Renato C.
Universidad Nacional Autónoma de México

Capitaine, Mireille
CNRS - University Toulouse 3

Cébron, Guillaume
Institut de Mathématiques de Toulouse

Charollois, Pierre
Université Paris 6

Cornean, Horia
Aalborg University

Courte, Sylvain
Université Grenoble Alpes

Crampé, Nicolas
CNRS - Université Montpellier

D'Ambrosio, Claudia
CNRS - École Polytechnique

Dancso, Zsuzsanna
The University of Sydney

Davison, Ben
The University of Edinburgh

De Bièvre, Stephan
Université des Sciences et Technologies de Lille

de Wiljes, Jana
University of Potsdam

Dembélé, Lassina
University of Warwick

Di Bernardino, Elena
Conservatoire national des arts et métiers

Dykema, Ken
Texas A&M University

Ford, Kevin
University of Illinois at Urbana-Champaign

Fraas, Martin
Virginia Tech

Ghiggini, Paolo
CNRS - Université de Nantes

Gleixner, Ambros
Zuse Institute Berlin

Granville, Andrew
Université de Montréal

Guillermou, Stéphane
Université Grenoble Alpes

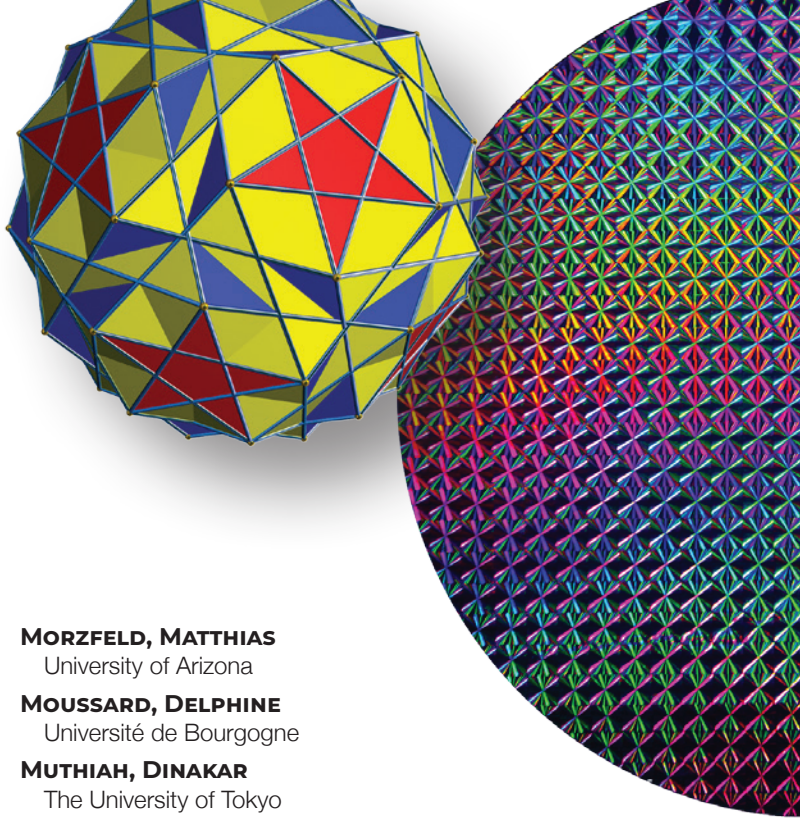
Harper, Adam J.
University of Warwick

Hendricks, Kristen
Michigan State University

Ito, Tetsuya
Osaka University

Joye, Alain
Université de Grenoble I

Kamnitzer, Joel
University of Toronto



Klopp, Frédéric
Université Pierre et Marie Curie

Kuno, Yusuke
Tsuda University

Lasserre, Jean-Bernard
CNRS - IMT Toulouse

Lee, Jon
The University of Michigan

Lukic, Milivoje
Rice University

Maillard, Pascal
Université Pierre et Marie Curie

Male, Camille
CNRS - Université de Bordeaux

Massuyeau, Gwénaël
Université de Bourgogne

Merkli, Marco
Memorial University of Newfoundland

Miller, Ezra N.
Duke University

Milton, John
The Claremont Colleges

Mingo, James A.
Queen's University

Mireles James, Jason D.
Florida Atlantic University

Mischaikow, Konstantin
Rutgers University

Misener, Ruth
Imperial College

Morzfeld, Matthias
University of Arizona

Moussard, Delphine
Université de Bourgogne

Muthiah, Dinakar
The University of Tokyo

Nachtergaele, Bruno
University of California at Davis

Naef, Florian
Massachusetts Institute of Technology

Nanda, Vidit
The Institute for Advanced Study

Nica, Alexandru
University of Waterloo

Novak, Jonathan
University of California

Nurbekyan, Levon
King Abdullah University of Science and Technology

Ogata, Yoshiko
The University of Tokyo

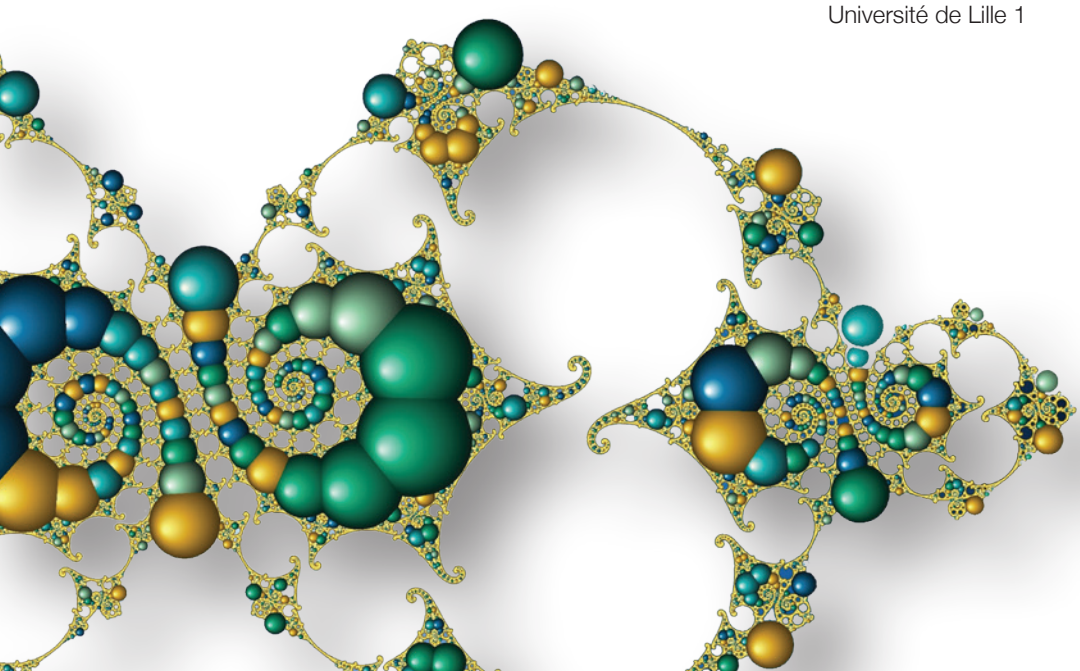
Osinga, Hinke
The University of Auckland

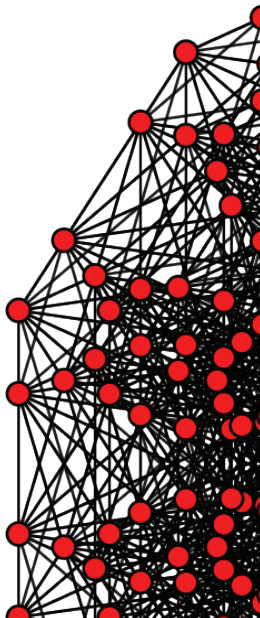
Piccirillo, Lisa
The University of Texas at Austin

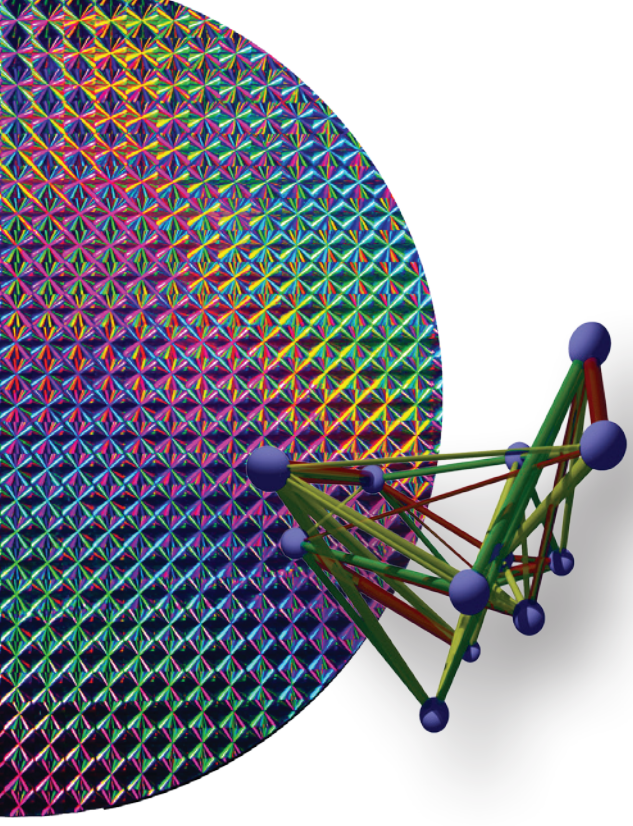
Pillet, Claude-Alain
Université du Sud Toulon-Var

Porta, Marcello
Universität Zürich

Potyagailo, Leonid
Université de Lille 1







Reich, Sebastian
Universität Postdam

Rejzner, Kasia
University of York

Rider, Brian
Temple University

Ridout, David
University of Melbourne

Ruuth, Steven
Simon Fraser University

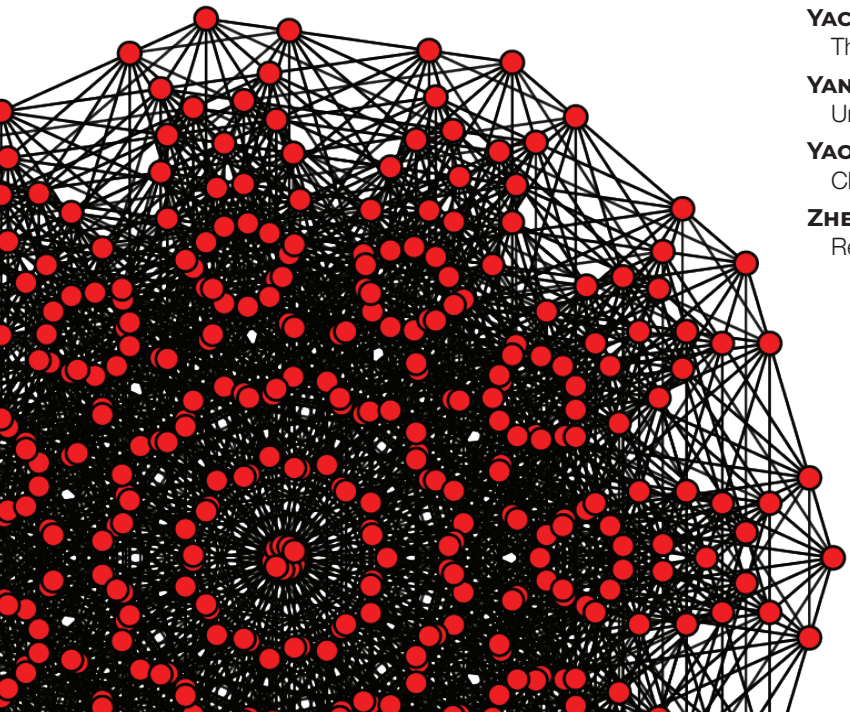
Schillings, Claudia
University of Mannheim

Shen, Linhui
Michigan State University

Shende, Vivek
University of California at Berkeley

Shepherd, Bruce
McGill University

Speicher, Roland
Saarland University



Spohn, Herbert
Technische Universität München

Stoffregen, Matthew
Massachussets Institute of Technology

Stuart, Andrew M.
California Institute of Technology

Su, Changjian
University of Toronto

Sullivan, Michael
University of Massachusetts

Suzuki, Sakie
Tokyo Institute of Technology

Teckentrup, Aretha L.
University of Edinburgh

Teufel, Stefan
Universität Tübingen

Tosun, Bülent
University of Alabama

Ueltschi, Daniel
University of Warwick

van den Berg, Jan Bouwe
Vrije Universiteit Amsterdam

van der Veen, Roland
Leiden University

van Willigenburg, Stephanie
University of British Columbia

Voiculescu, Dan-Virgil
University of California at Berkeley

Warzel, Simone
Technische Universität München

Watson, Liam
University of British Columbia

Yacobi, Oded
The University of Sydney

Yang, Lu
University of Amsterdam

Yao, Guangming
Clarkson University

Zhedanov, Alexei
Renmin University of China

Aisenstadt Chairs

The Aisenstadt chair, founded thanks to a donation from Dr. André Aisenstadt, allows renowned mathematicians to be hosted for a period of at least one week (ideally one or two months). During their stay, these researchers give a series of lectures on a specialized topic, the first of which, at the request of the donor André Aisenstadt, must be accessible to a large audience.

The CRM is proud to subscribe to the Université de Montréal's policy on adapting to cultural diversity and is committed to taking into account the diversity and the systemic and individual barriers to access (for example, related to ethnic origin, gender, disability) when selecting researchers.

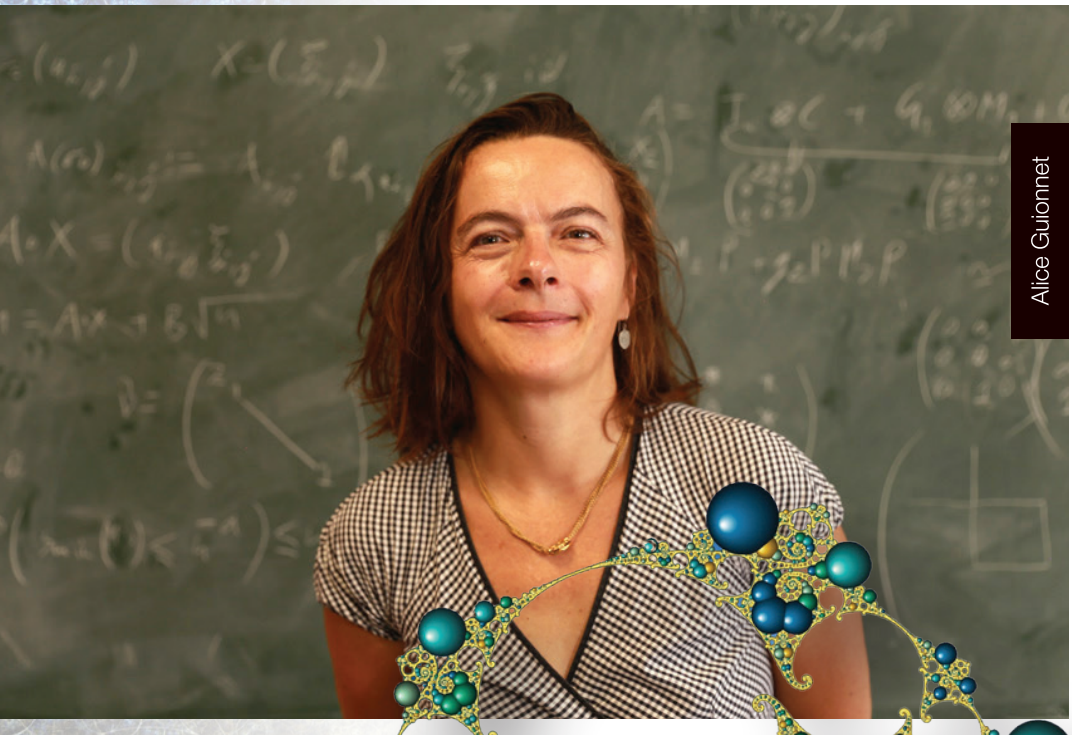
The research areas of the Aisenstadt chairholders are generally closely related to the themes of the current year's thematic programs. The 2018-2019 Aisenstadt chairholders were Alice Guionnet, Svetlana Jitomirskaya, Mireille Bousquet-Mélou, Michael Aizenman, and Robert Seiringer. The 2019-2020 chairholders were Éva Tardos, Hiraku Nakajima and Ciprian Manolescu.

2018-2019 Aisenstadt Chair recipients

Alice Guionnet

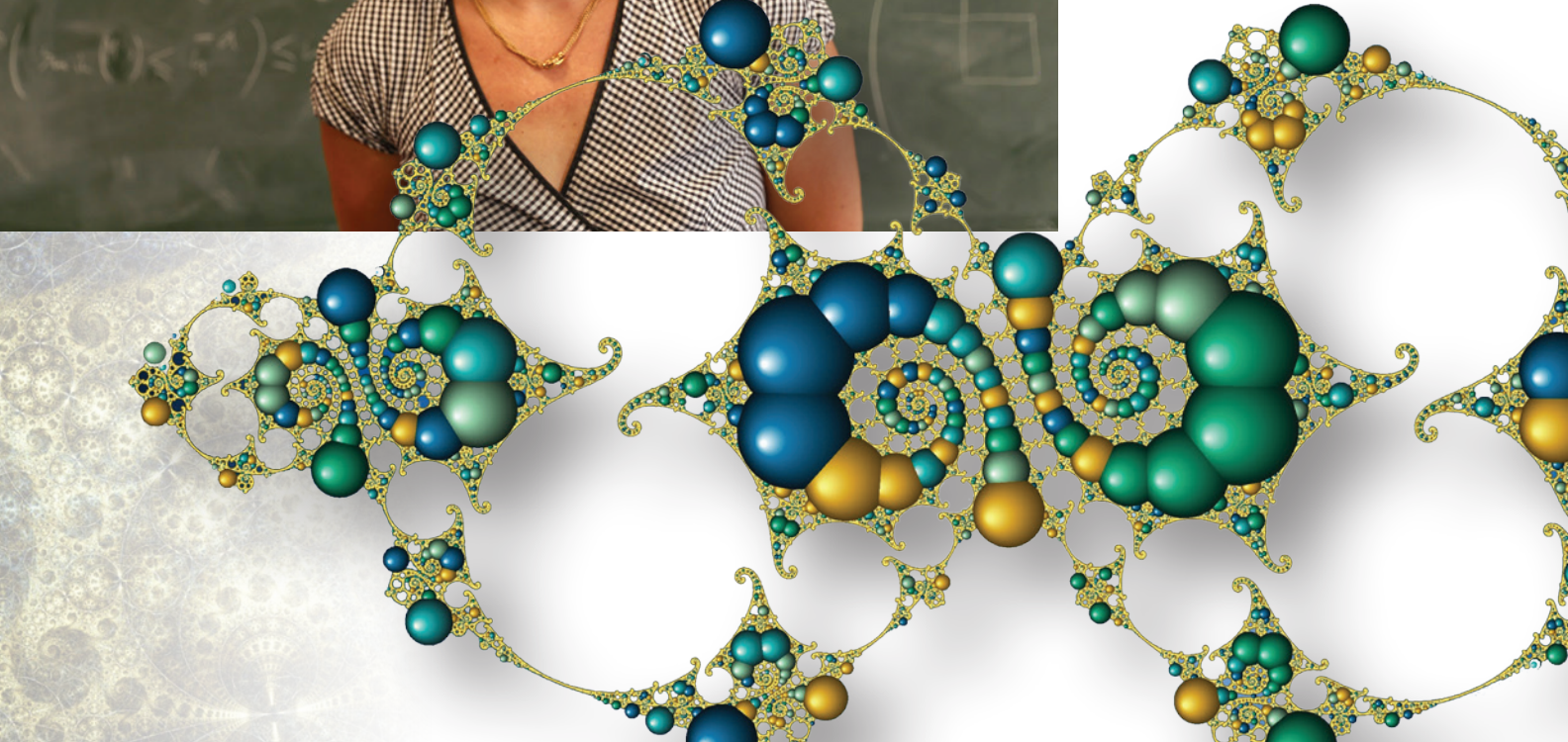
(CNRS, École Normale Supérieure Lyon)

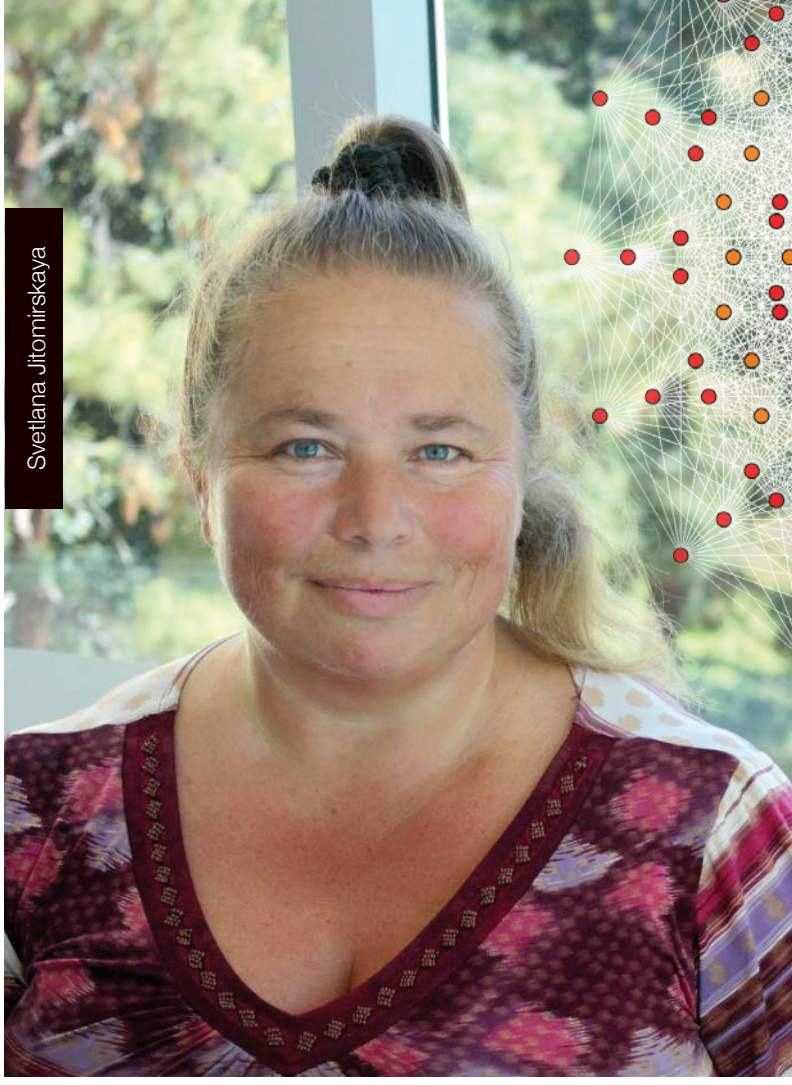
Alice Guionnet is a world-renowned leader in the field of probability, notably for her fundamental work in the theory of random matrices and in free probability. Her numerous scientific contributions include four books and about 80 research articles. Guionnet's numerous honors include the Rollo Davidson Prize (2003), the Loève Prize (2009), the CNRS Silver Medal (2010). She is a Chevalier de la Légion d'honneur (2012), and the Blaise Pascal Medal of the European Academy of Sciences (2018). She was an ICM guest lecturer in 2006 and was a member of the prize selection committee for the 2018 Fields Medals. She was elected in 2017 to the French Academy of Sciences. Previously, she served on the CRM International Scientific Committee (2007-2011), on the scientific committee of the 2008-2009 CRM thematic year on probabilistic methods in mathematical physics, and taught a one-month master's course on random matrices, free probability, and card enumeration at the 2015 CRM-PIMS summer school in probability.



Alice Guionnet

As part of her Aisenstadt chair, Alice Guionnet stayed at CRM from March 20-25, 2019 as part of the workshop Free Probability: the applied perspective and gave three lectures: on March 20, 22 and 25.





Svetlana Jitomirskaya

Svetlana Jitomirskaya
(UC Irvine)

Svetlana Jitomirskaya works on dynamical systems and mathematical physics. She received her PhD from Moscow State University in 1991. She joined the Department of Mathematics at the University of California, Irvine where she became a full professor in 2000. She is best known for solving the "Ten Martini" problem with the mathematician Artur Ávila. In 2005, she was awarded the Ruth Lyttle Satter Prize in Mathematics for her pioneering work in quasi-periodic nonperturbative localization. She was an invited speaker at the 2002 International Congress of Mathematicians in Beijing. She was also awarded a Sloan Fellowship in 1996. In 2018, she was elected to the American Academy of Arts and Sciences.

As part of her Aisenstadt chair, Svetlana Jitomirskaya stayed at the CRM on November 12-13, 2018 during the workshop on Spectral Theory of Quasi-Periodic and Random Operators (November 12-16) and gave three lectures: two on November 12 and the third on November 13.

Mireille Bousquet-Mélou

Mireille Bousquet-Mélou
(CNRS, University of Bordeaux)

Mireille Bousquet-Mélou is a research director at the CNRS (France). Her research interests include enumerative combinatorics, its application to the study of large random objects and its links with statistical physics. Her research covers several fields and has been published in mathematics, physics and computer science journals. She is attached to the LaCIM, one of the most important CNRS research laboratories, whose combinatorics team has had close links with the LaCIM for more than thirty years. She is also in charge of the International Associated Laboratory (LIA) of combinatorics Lirco, created in 2011. The latter supervises the cooperation between the LaCIM and about fifty researchers in France. Recipient of several awards, her work was rewarded by the CNRS Silver Medal in 2014, one of the highest distinctions in research.

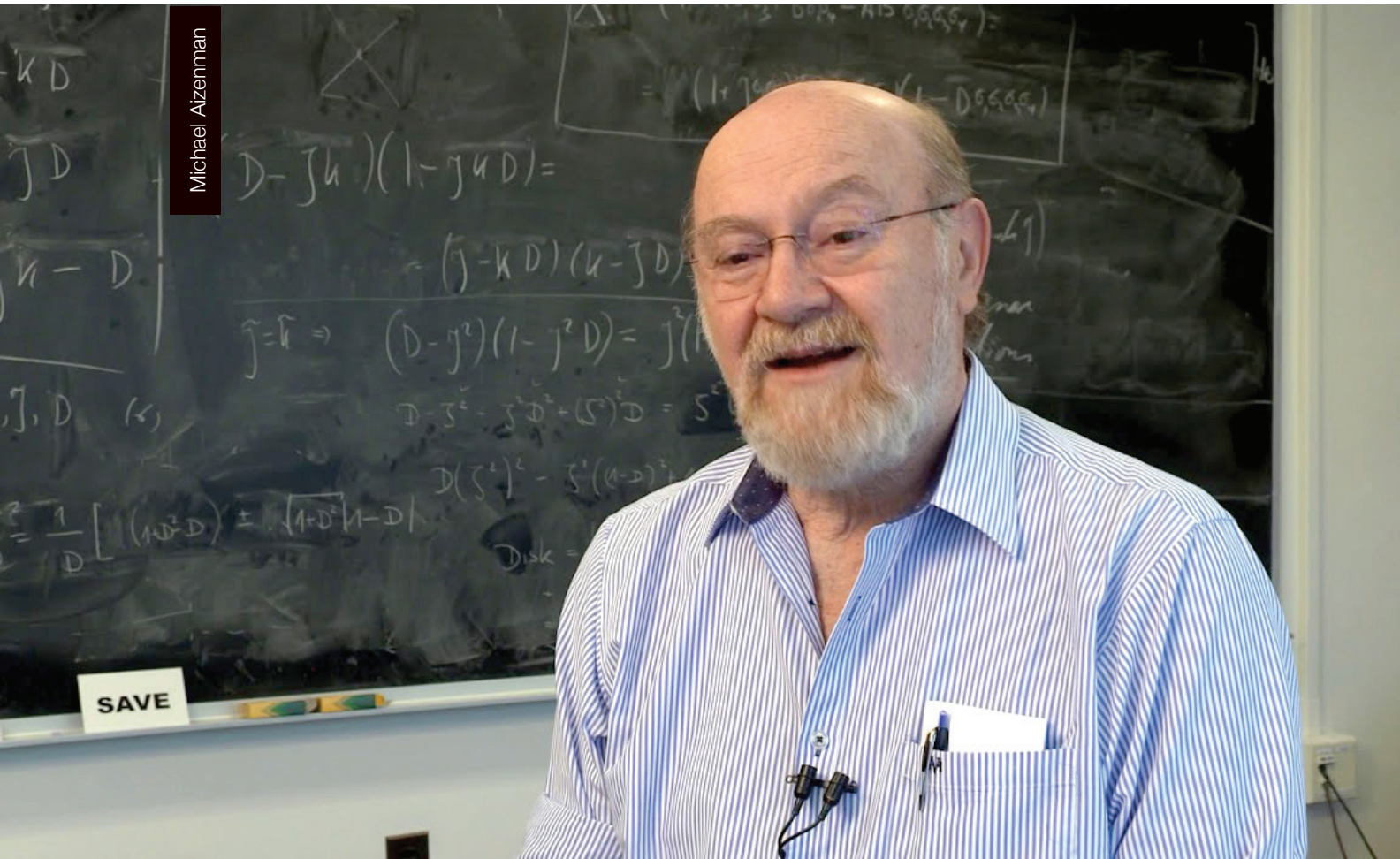
Mireille Bousquet-Mélou is a member of the editorial board of several journals dedicated to combinatorics and has organized numerous scientific activities in the field. She has also participated in scientific committees at the "Institut des Sciences Mathématiques et ses interactions avec le CNRS (INSMI)" and at the "Fondation des Sciences Mathématiques de Paris".

As part of her Aisenstadt chair, Mireille Bousquet-Mélou stayed at the CRM from October 1-5, 2018 during the activities organized by the "Laboratoire de Combinatoire et d'Informatique Mathématique (LaCIM)" during the CRM 50th anniversary thematic semester and gave three lectures: on October 1, 2 and 3.

Michael Aizenman
(Princeton University)

Michael Aizenman is a mathematical physicist at Princeton University. He received his Ph.D. in 1975 from Yeshiva University (Belfer Graduate School of Science), New York. After postdoctoral positions, he was appointed Assistant Professor at Princeton. In 1982, he went to Rutgers University as an associate and then full professor. In 1987 he moved to the Courant Institute and in 1990 he returned to Princeton as a professor of mathematics and theoretical physics. In 1990 he was awarded the Norbert Wiener Prize of the AMS and SIAM for his outstanding contribution to original and non-perturbative mathematical methods in statistical mechanics, by which he was able to solve several long and important problems concerning critical phenomena, phase transitions and quantum field theory. More recently, he has worked on the quantum effects of distorted disorders. A member of the National Academy of Sciences since 1997, he is also a laureate of the Brouwer Medal (2002) of the Royal Dutch Mathematical Society and the Royal Dutch Academy of Arts and Sciences, and an honorary doctor of the University of Cergy-Pontoise (2009). He is one of the organizers of the joint CRM-PCTS workshop to be held in Princeton in October 2018.

As part of his Aisenstadt chair, Michael Aizenmann stayed at the CRM from September 17 to November 16, 2018 in the framework of the thematic semester “Mathematical challenges in many-body physics and quantum information” and gave three lectures: on September 24, 25 and 27.



Michael Aizenman

Robert Seiringer
(IST Austria)

Robert Seiringer studied physics at the University of Vienna where he received his PhD in 2000. With a Schrödinger Fellowship, in 2001 he went to Princeton University. From 2010 to 2013, he has been a professor at McGill University. He is now at the Institute of Science and Technology Austria (IST Austria). He received a Sloan Fellowship in 2004, the Henri Poincaré Prize in 2009 and the Steacie Memorial Fellowship in 2012. He was an invited speaker at the International Congress of Mathematicians in 2014. He is a corresponding member of the Austrian Academy of Sciences since 2017 and has been President of IAMP. Robert Seiringer and his research group focus on N-body systems in quantum mechanics. In particular, they are interested in problems in quantum statistical mechanics and condensed matter physics. Such systems display a wide variety of complex phenomena, and it is of fundamental importance to understand the underlying principles as deeply and precisely as possible.

As part of his Aisenstadt chair, Robert Seiringer visited the CRM from September 10-14, 2018. Robert Seiringer's lectures were part of the N-body Quantum Mechanics Workshop (September 10-14) and he gave three lectures: on September 10, 12 and 13.

Robert Seiringer

2019-2020 Aisenstadt Chair recipients

Éva Tardos
(Cornell University)

Éva Tardos received her Dipl.Math. in 1981, and her Ph.D. 1984, from Eötvös University, Budapest, Hungary. She joined Cornell in 1989, and was Chair of the Department of Computer Science 2006-2010. She has been elected to the National Academy of Engineering, National Academy of Sciences, and the American Academy of Arts and Sciences, is an external member of the Hungarian Academy of Sciences, and is the recipient of a number of fellowships and awards including the IEEE John von Neumann Medal, Packard Fellowship, the Gödel Prize, Dantzig Prize, and the Fulkerson Prize. She was editor-in-Chief of SIAM Journal of Computing 2004-2009, and is currently editor-in-Chief of the Journal of the ACM, and editor of some other journals including the Theory of Computing, and Combinatorica.

On November 11, 2019, she was also named the Cornell Information Science Associate Dean for Diversity and Inclusion, this position is an extension of the roles Professor Tardos has been playing in leading Cornell's initiatives. Tardos's research interests are algorithms and algorithmic game theory, an area concerned with designing and analyzing systems and algorithms for selfish users.

Her research focuses on algorithms and games on networks. She is most known for her work on network-flow algorithms, approximation algorithms, and quantifying the efficiency of selfish routing.

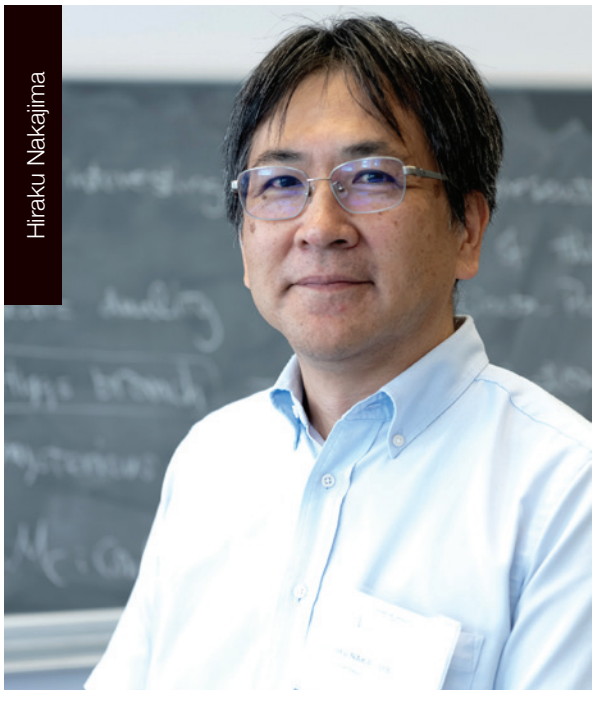

Éva Tardos

As part of her Aisenstadt chair, Eva Tardos gave an initial lecture on January 17, 2020 in the framework of the thematic semester “The mathematics of decision making” but was unable to complete the rest of her lectures due to COVID-19.

Hiraku Nakajima
(Tokyo University)

Hiraku Nakajima received his Ph.D. in 1991 from the University of Tokyo. Nakajima began his academic career as a research assistant at the University of Tokyo. He became professor and principal investigator at Kavli Institute for the Physics and Mathematics of the Universe in 2018. Nakajima received both the Geometry Prize (1997) and the Spring Prize (2000) from the Mathematical Society of Japan. He was a plenary speaker at the International Congress of Mathematicians (Beijing, 2002). He has also received the 2005 JSPS Prize of the Japan Society for the Promotion of Science, the 2014 Japan Academy Prize, and the Asahi Prize. Nakajima’s research interests include geometry, representation theory, and mathematical physics. He is particularly known for the development of the theory of quiver varieties. Other major accomplishments include his proofs of Nekrasov’s conjecture and the AGT conjecture, both geometric conjectures, which originated in physics.

Professor Hiraku Nakajima was at CRM from August 11 to 24, 2019. Professor Nakajima gave a series of three lectures on August 19, 21 and 23.

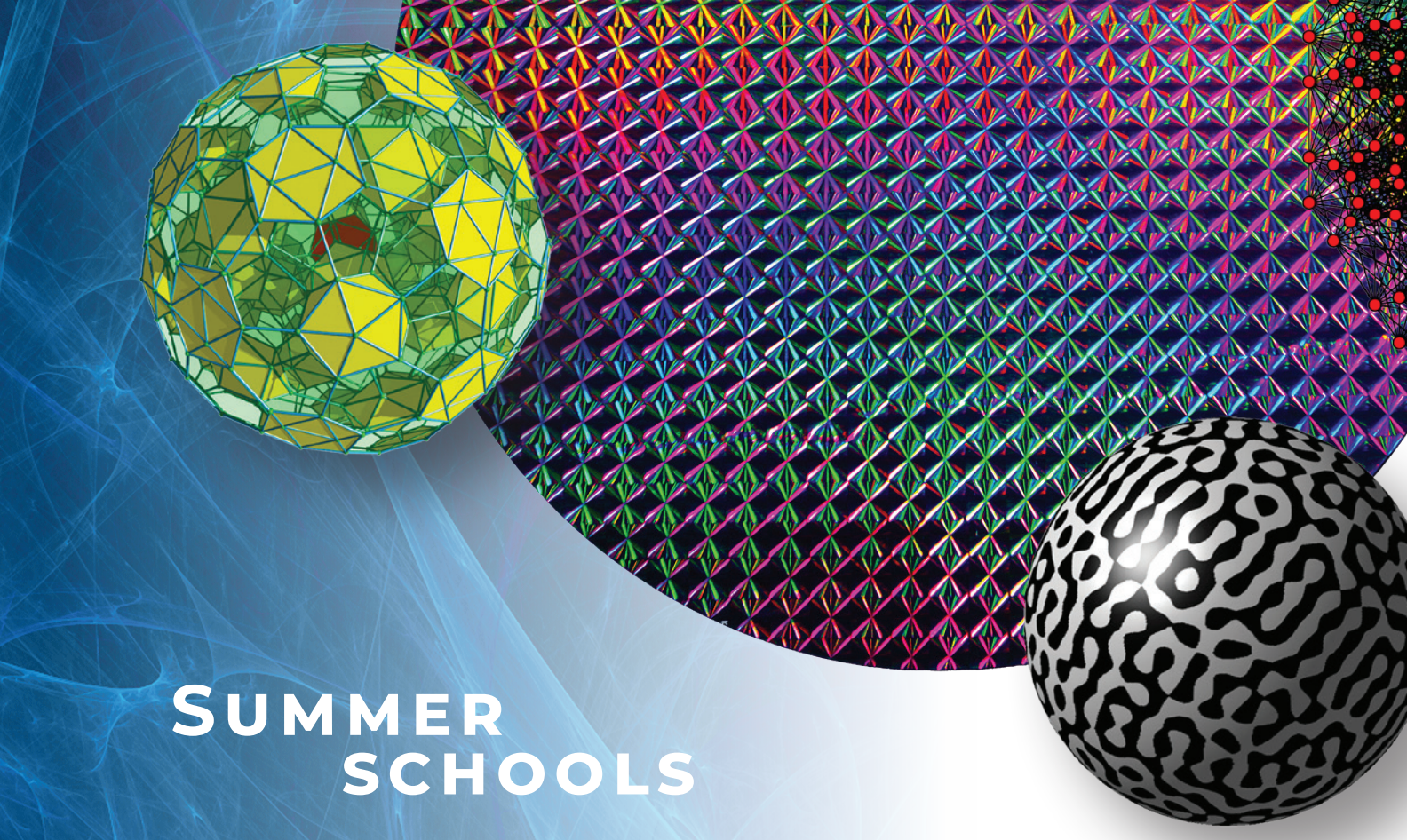

Hiraku Nakajima


Ciprian Manolescu

Ciprian Manolescu
(UCLA)

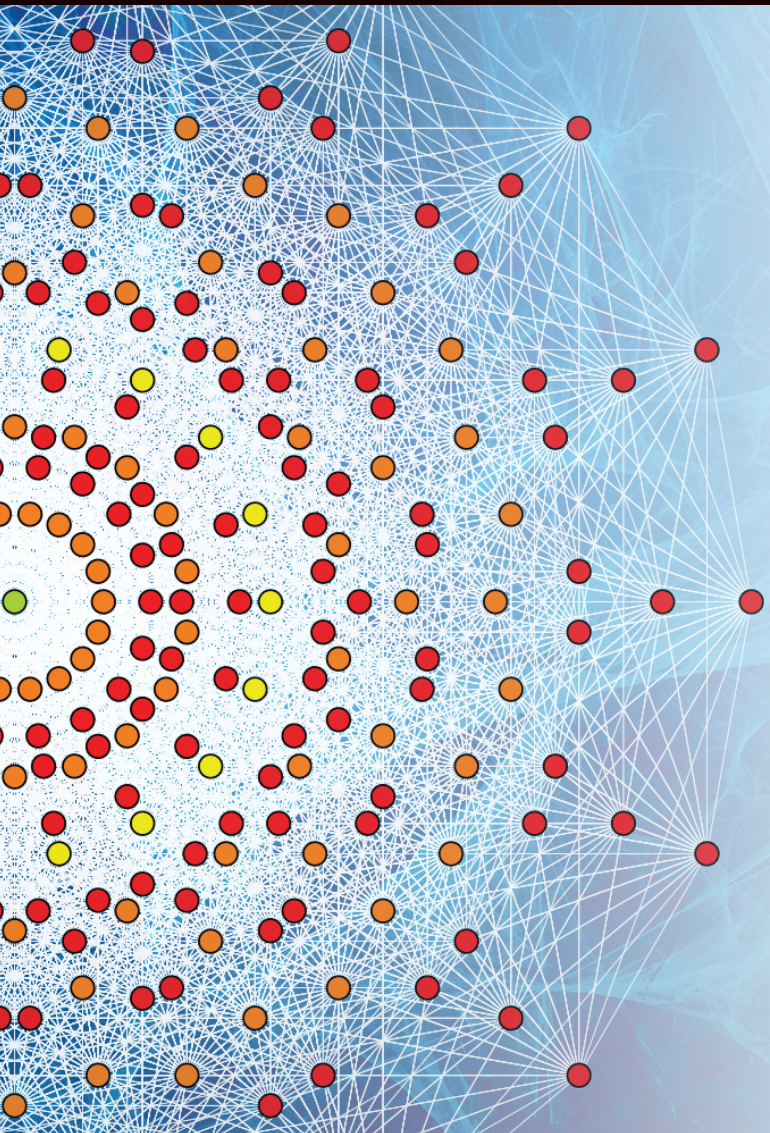
Ciprian Manolescu is a Romanian-American mathematician working in gauge theory, symplectic geometry, and low-dimensional topology. Among his many important research contributions, he was instrumental in establishing combinatorial definitions in Heegaard Floer Homology and in producing a celebrated disproof of the triangulation conjecture through the development and application of Pin(2) equivariant Floer homology. His many accolades include a Clay Research Fellowship (2004-2008) as well as a 2012 European Mathematical Society Prize “for his deep and highly influential work on Floer theory, successfully combining techniques from gauge theory, symplectic geometry, algebraic topology, dynamical systems and algebraic geometry to study low-dimensional manifolds.» He was elected as a member of the 2017 class of Fellows of the American Mathematical Society “for contributions to Floer homology and the topology of manifolds». In 2018 he delivered an invited talk at the 2018 International Congress of Mathematicians in Rio de Janeiro.

Within the framework of his Aisenstadt chair, Ciprian Manolescu gave four lectures, in 2019, on August 30 and from September 3 to 5.



Summer Schools

The CRM sponsors the annual Senior Mathematics Seminar (SMS). In addition, it organizes or supports other schools. They are listed below.



SMS 2018 Summer School

11-22 June 2018

Derived Geometry and Higher Categorical Structures in Geometry and Physics,
Fields Institute

Organizers: *Anton Alekseev (University of Geneva); Ruxandra Moraru (University of Waterloo); Chenchang Zhu (Georg-August University of Gottingen)*

The summer school focused on the following four topics: higher categorical structures in geometry, derived geometry, factorization algebras, and their application in physics. There were eight to ten mini-courses on these topics, including mini-courses led by Chirs Brav, Kevin Costello, Jacob Lurie, and Ezra Getzler.

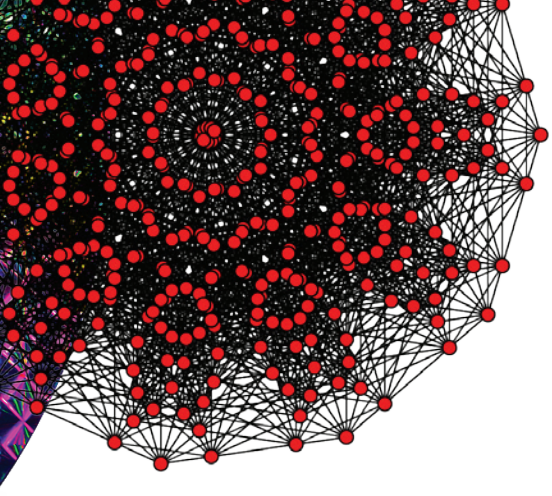
This annual school, which took place for its 56th edition at the Fields Institute, has as institutional partners the CRM, the MSRI, PIMS the ISM, the CMS and the University of Montreal.

CRM Summer School 2018

8-13 July 2018

Statistical Genetics,
Laval University

Organizers: *Alexandre Bureau (Laval University); Celia M. T. Greenwood (Lady Davis Institute for Medical Research); Aurélie Labbe (HEC Montreal); Lajmi Lakhal Chaieb (Laval University); Marie-Hélène Roy-Gagnon (University of Ottawa)*



The goals of the school were: Introduce statistical genetics to students with a statistical background; Learn to identify the major statistical challenges in statistical genetics; Learn to apply existing methods for the analysis of genetic data by taking their specificities into account.

The mini-courses covered the following topics: Functional genetics (Sunduz Keles, Wisconsin); Genetic association (Kathryn Lunetta, Boston); Quantitative traits (Fei Zou, Florida); Rare variants (Ruzong Fan, Georgetown); Methylation analysis (Celia Greenwood, McGill); Population genetics (Fabrice Larribe, UQAM); Basic concepts (Alexandre Bureau, ULaval).

Training School

8-10 May 2019

"Machine Learning" (Eldad Haber, NSERC Industrial Research Chair in Computational Geoscience), "Data Assimilation" (Sebastian Reich, University of Potsdam), "Inverse Problems" (Andrew Stuart, California Institute of Technology), CRM

Organizers: *Antony R. Humphries (McGill University); Sebastian Reich (Universität Potsdam); Andrew M. Stuart (California Institute of Technology)*

The aim of this training school was to build the mathematical and computational foundations that underpin the subjects of data assimilation (DA) and machine learning (ML). It was targeted at both graduate students in the mathematical sciences and in the application areas in which DA and ML techniques are being applied. The training school enabled participants to be properly equipped to engage in the workshops that were a part of the thematic program.

SMS 2019 Summer School

1-12 July 2019

Current Trends in Symplectic Topology, University of Montreal

Organizers: *Octav Cornea (University of Montreal); Yakov Eliashberg (Stanford University); Michael Hutchings (UC Berkeley); Egor Shelukhin (University of Montreal)*

Symplectic topology is a rapidly developing branch of geometry that has seen phenomenal growth in the last twenty years. The objectives of the two weeks, organized in the setting of the "Séminaire de Mathématiques Supérieures", were to survey some of the key directions of development in the subject today thus covering: advances in homological mirror symmetry; applications to hamiltonian dynamics; persistent homology phenomena; implications of flexibility and the dichotomy flexibility/rigidity; legendrian contact homology; embedded contact homology and four-dimensional holomorphic techniques and others.

With the collaboration of many of the top researchers in the field today, the school served as an introduction and guideline to students and young researchers who were interested in accessing this diverse subject.

Summer School on Nonlinear Dynamics in Life Sciences

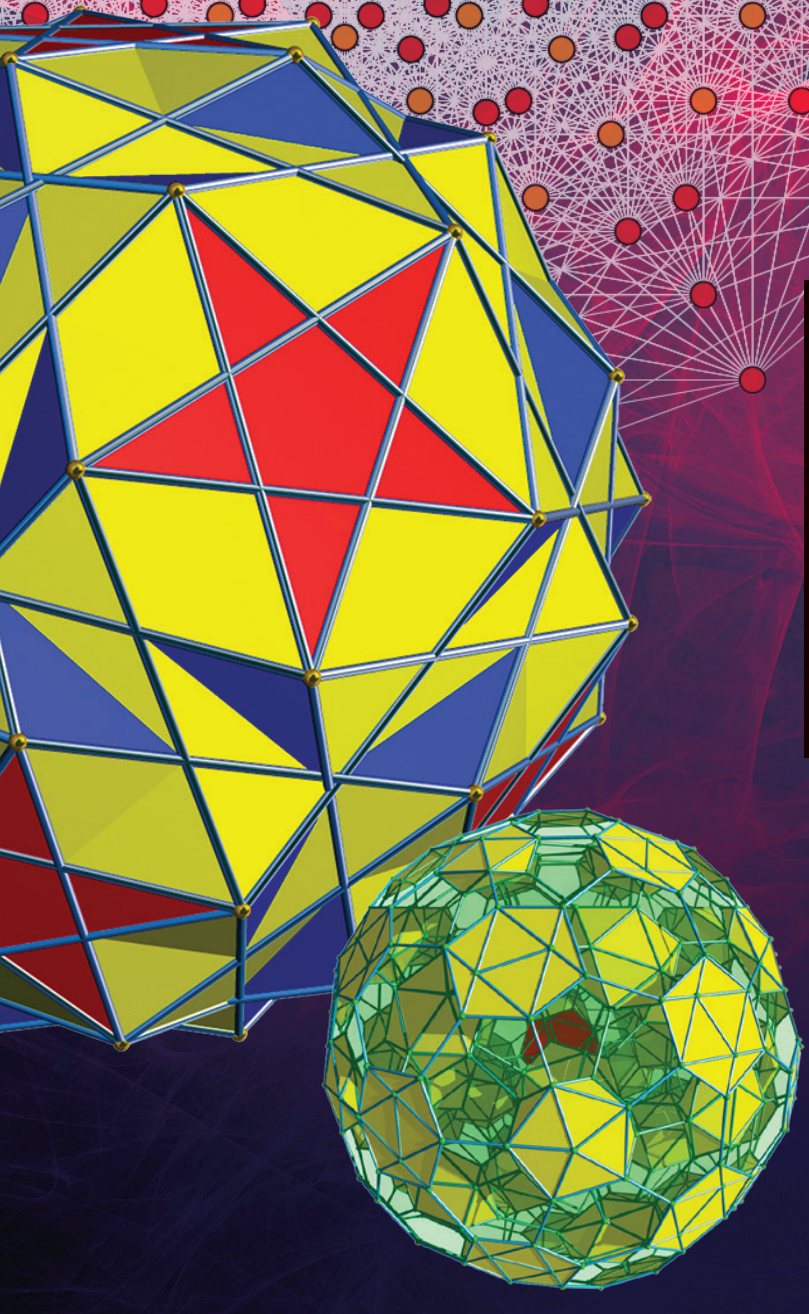
15-19 July 2019

Summer School, Fields Institute

Organizers: *Anmar Khadra (McGill University); Sivabal Sivaloganathan (University of Waterloo)*

Living systems are typical examples of dynamical systems with many interrelated parts or subsystems, from small-scale cellular relationships to large-scale population relationships. Nonlinear dynamics arise when the behavior of one subsystem, with its own dynamics, becomes the input for another subsystem, imposing certain constraints on its dynamics.

Other activities



The CRM organizes and sponsors several other activities in various fields of mathematics. They can be part of the so-called general program for activities held at the CRM or outside its facilities or organized by other institutions. They can also be part of the interdisciplinary and industrial program or organized by the laboratories.

The General Program is used to fund a variety of scientific events, from highly specialized workshops for a small number of researchers to conferences with hundreds of attendees. The general program aims to encourage the development of research in the mathematical sciences at all levels. The program is flexible, and projects are considered as they are proposed.

Activities held at the CRM

May 21 – June 1st, 2018

Workshop on Probability in Number Theory

Organizers: *Andrew Granville (Université de Montréal); Dimitris Koukoulopoulos (Université de Montréal); Maksym Radziwill (Caltech)*

May 30 – June 1st, 2018

Statistical Inference for Complex Surveys

Organizers: *David Haziza (Université de Montréal); Changbao Wu (University of Waterloo)*

July 16-20, 2018

Algebraic Methods in Mathematical Physics - Satellite Meeting at ICMP 2018

Organizers: *Pascal Baseilhac (CNRS – University of Tours); Peter Bouwknegt (The Australian National University); David Ridout (University of Melbourne); Yvan Saint-Aubin (Université de Montréal); Luc Vinet (Université de Montréal)*

December 11-14, 2018

Workshop on Mathematical and Computational Methods for Quantum Systems

Organizers: *Xavier Antoine (University of Lorraine); André D. Bandrauk (University of Sherbrooke); Yong-Yong Cai (Beijing Computational Science Research Center); Emmanuel Lorin De La Grandmaison (Carleton University)*

January 22-25, 2019

Nirenberg Lectures in Geometric Analysis by Vadim Kaloshin

Organizers: *Pengfei Guan (McGill University); Dmitry Jakobson (McGill University); Iosif Polterovich (Université de Montréal); Alina Stancu (Concordia University)*

May 1-22, 2019

CRM-UMI Meeting

Organizers: *Emmanuel Giroux (Unité Mixte Internationale CNRS-CRM)*

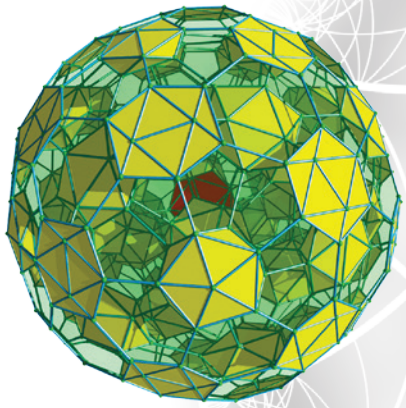
The aim of the meeting was to take advantage of the visit of a number of French mathematicians to the CRM to have them talk about various topics and to take this opportunity to discuss the role of the UMI in mathematical exchanges between Quebec and France.

May 13-17, 2019

The Ninth Montreal Industrial Problem Solving Workshop

Organizers:: *Nancy Laramée (Director of Partnerships (IVADO)); Odile Marcotte (Deputy Director, Partnerships (CRM)); Stéphane Rouillon (Partnership Advisor (IVADO)); Jean-Marc Rousseau (Director of Technology Transfer (IVADO))*

The Ninth Montreal Industrial Problem Solving Workshop was organized jointly by the Centre de recherches mathématiques (CRM) and the Institute for Data Valorization (IVADO). The workshop gathered representatives from industry, academic mathematicians, graduate students, and postdoctoral fellows. Participants worked in teams, each of which studied a concrete problem submitted by a company or a public or quasi-public institution. One of the goals of the workshop (IPSW) is to provide companies and institutions with mathematical tools for solving problems. An IPSW also allows professors and students in the mathematical sciences (including data science, statistics, optimization, mathematical finance, natural language processing, etc.) to analyze and solve real-world problems. The organizers viewed the workshop as an “incubator” of collaborations and hope that the work initiated during the workshop will lead to collaborations lasting several months or years.



The Montreal workshop was part of a Canadian tradition, since PIMS (the Canadian institute based in Western Canada) started organizing such workshops twenty years ago (see www.pims.math.ca/industrial). In Toronto the Fields Institute is also organizing problem solving workshops (see for instance the site of the workshop that took place in August 2016). The Canadian workshops have been designed on the model of the "study groups" pioneered by the University of Oxford (see www.maths-in-industry.org). The CRM, the FI, and PIMS take turns organizing "national" workshops: the CRM and IVADO are proud to have hosted a national workshop in 2019.

July 1-26, 2019

SMB2019 – Annual Meeting of the Society for Mathematical Biology (SMB): From Genome to Biome

Organizers: *Jacques Bélair (Université de Montréal); Frédéric Guichard (McGill University); Anmar Khadra (McGill University)*

The annual meeting of the Society for Mathematical Biology (SMB) brought together a record number of 623 participants from 27 countries from 21 to 26 July 2019. Its theme "From Genome to Biome" reflected the diverse application of the mathematical theories and methods presented, which were deployed at all scales of biological organization. Up to 11 parallel sessions were concentrated in the Claire-McNicoll Pavilion, which allowed the participants to be physically together and to maximize interactions, particularly during breaks.

The majority of the attendees were students or post-docs, with just 283 identifying themselves as professors; the gender distribution, although not completely egalitarian (the plenary lectures were), nevertheless included 41% female participation.

Sustained external activities

May 28 – June 1st , 2018

Workshop on "Shimura Varieties and Hyperbolicity of Moduli Spaces"

UQÀM

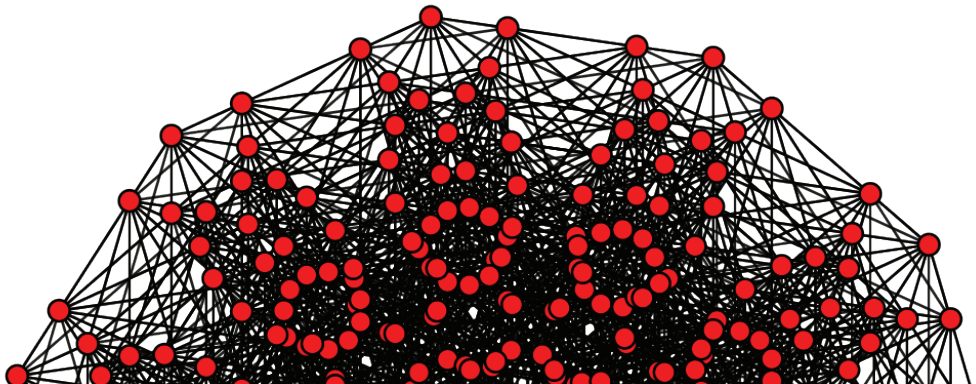
Organizers: *Steven Shin-Yi Lu (UQÀM); Marc-Hubert Nicole (Institut mathématique de Marseille); Erwan Rousseau (Aix-Marseille University)*

June 2, 2018

The 6th Congress of Students in Statistics

McGill

Organizers: *Russell Steele; Andrea Benedetti; Masoud Asgharian; Robert Platt; Yi Yang*



June 2-6, 2018

Characters in Low-Dimensional Topology: A Lecture in Honor of Steven Boyer

UQÀM

Organizers: *Olivier Collin (UQÀM); Stefan Friedl (Universität Regensburg); Stephan Tillmann (University of Sydney); Cameron Gordon (University of Texas at Austin); Liam Watson (University of Sherbrooke)*

July 9-13, 2018

Theory Canada 13 Conference – CNTA XV Pan-Canadian Number Theory Conference

Laval University

Organizers: *Hugo Chapdelaine; Jean-Marie De Koninck; Antonio Lei; Claude Levesque*

Scientific committee: *Kathrin Bringmann (University of Cologne); Nils Bruin (Simon Fraser University); Gérard Freixas (CNRS - Institut de Mathématiques de Jussieu); Stephen Kudla (University of Toronto); Matilde Lalin (Université de Montréal); Antonio Lei (Laval University); Christelle Vincent (University of Vermont)*

August 17, 2018

2018 Diversity in Mathematics

University of British Columbia

Organizers: *Malabika Pramanik (UBC); Malgorzata Dubiel (SFU); Veselin Jungic (SFU); PIMS*

August 19-24, 2018

2018 Industrial Problem Solving Workshop (IPSW)

University of Calgary

Organizer: *Cristian Rios (University of Calgary, PIMS Site Director); Michael Lamoureux (University of Calgary, PIMS Innovation Coordinator); Odile Marcotte (UQÀM, CRM Deputy Director, Partnerships); Tom Salisbury (York University, Fields Associate Director, Industry Liaison).*

The Institutes' Industrial Problem Solving Workshops (IPSW) aim to create mutually beneficial links between industrial researchers and their counterparts in academia, with a focus on mathematical, statistical, and computational problems that arise in real industrial settings. With generous funding from the Natural Sciences and Engineering Research Council, the IPSW and related events form a key component of industrial activity for the institutes.

The goal of the IPSW is to connect industries with faculty, postdoctoral fellows and graduate students with expertise in industrial case-studies. This interaction is fostered in the specific context of a problem-solving session over 5 days. The case-studies in question have had a substantial impact on the mathematical and statistical content and have in many cases led to industrial collaborations and developments.

May 6-10, 2019

Geometrization of the Local Langlands Program

McGill

Organizers: *Eyal Goren; Henri Darmon*

Keynote speaker: *Jared Weinstein (Boston University)*

May 10-11, 2019

The Earth of Tomorrow: Can Math Help?

As part of 24 hours of science 2019

Organizer: *Christiane Rousseau (CRM and Université de Montréal)*

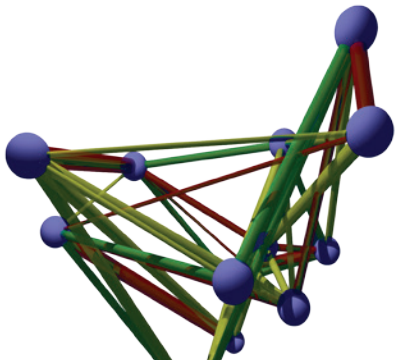
- "Challenges and opportunities of tomorrow's transport: more than a traffic issue!" Speaker: Geneviève Boisjoly (Polytechnique Montreal and CIRRELT)
- "How to assess the risks of environmental disasters?" Speaker: Christian Genest (McGill University)
- "Maths and Magic": Workshop led by Nadia Lafrenière and Mélodie Lapointe (UQÀM)

May 13-15, 2019

R à Québec 2019

Laval University

Organizers: *Alexandre Bureau (Laval University); Pierre Racine (Laval University); Jean-François Coeurjolly (University of Grenoble Alpes); Aurélie Labbe (HEC Montréal)*



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The 7th Canadian D
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Johannes Carmes
David Conlo
Anna R. Karlin,
Mike Mol
Peter Nels
Rekha Thomas

Publ

Bill Coo

Invited Minisymposia

Additive combinatorics, Algebraic and geometr
Combinatorial optimization, Computational me
Discrete geometry, Enumerative combinatorics
Matroid theory, Random graphs, Structural gra

Program Committee

Rick Brewster, Vida Dujmović, Jim Geelen, An
Catherine McGeoch, Pawel Pralat, Sakat Sau
Jozsef Solymosi, Maya Stein, Einar Steingrím

Local Arrangements Committee

Pavol Hell, Jonathan Jedwab (Chair), Marni M

Satellite Conference

...celebration of The Electronic Jou

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rence (CanaDAM 2019)
Vancouver, May 28-31, 2019
dam.math.ca/2019/

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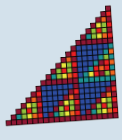
urnal of Combinatorics  on May 27, 2019

May 13-17, 2019

A research workshop with minicourse: Diophantine Approximation and Value Distribution Theory at the Interface of Arithmetic and Complex Hyperbolic Geometry

UQÀM

Organizer: *Steven Lu (UQÀM); Marc-Hubert Nicole (Institut mathématique de Marseille); Nathan Grieve (Tutte Institute for Mathematics and Computing); Aaron Levin (Michigan State University); William Gasarch (University of Maryland); Erwan Rousseau (University of Aix-Marseille); Min Ru (University of Houston)*

May 22-24, 2019

Atlantic Causal Inference Conference 2019

McGill

Organizer: *Mireille Schnitzer (Université de Montréal); Ian Shrier (McGill University); Russell Steele (McGill University); Robert W. Platt (McGill University)*

May 25, 2019

The 7th Canadian Congress of Students in Statistics

University of Calgary

May 28-31, 2019

CanaDAM 2019: Seventh Canadian Conference on Discrete and Algorithmic Mathematics

Simon Fraser University

Organizer: *Pavol Hell; Jonathan Jedwab; Marni Mishna; Bojan Mohar; Amarpreet Rattan*

May 30, 2020

The 8th Annual Canadian Statistics Student Conference (online)

Carleton University

Organizer: *Francis Duval (UQÀM); Gengming He (University of Toronto)*

The opening lecture was given by Dr. David Haziza (Université de Montréal, Canada).

Grandes conférences publiques

The Secret Life of Mathematics

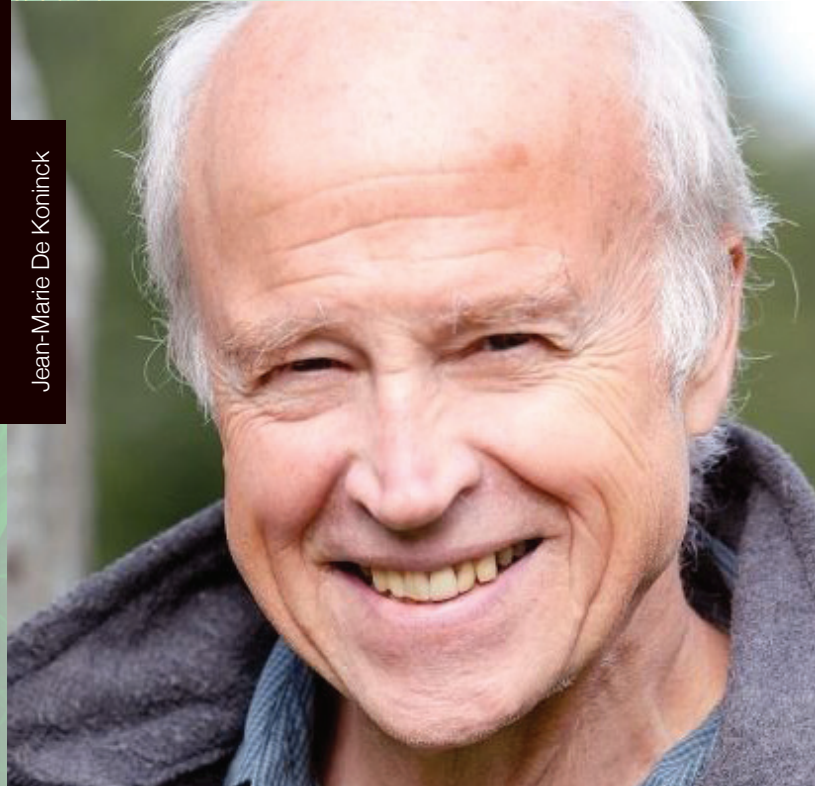
Jean-Marie De Koninck, Laval University

July 12, 2018

It is well known that intuition is at the very center of the mathematician's activity. However, when faced with certain problems, intuition can play tricks on him. Indeed, the solution is often well hidden and not only does intuition not always lead to it, but it can even lead away from it. By means of selected examples in geometry, probability theory and number theory, we will illustrate some of the traps that lie in wait for the mathematician. Thus, after presenting two famous conjectures, each of them quite plausible, we will establish that at least one of them must be false.

In the spring of 2006, the CRM launched the "Grandes Conférences publiques du CRM" (Grand Public Lectures) in order to meet the expectations of a public that is curious to understand the major events in the mathematical sciences. They feature experienced speakers who are able to communicate the beauty and power of cutting-edge mathematical research in a language that is accessible to all.

In 2018-2019, five lectures were given at the Université de Montréal: "The Secret Life of Mathematics" by Jean-Marie De Koninck, "The Discrete Charm of Geometry" by Alexander Bobenko, "The mathematics of beauty" by Mina Teicher, "Understanding Animal Movement Patterns With a Mathematical Eye" by Mark Lewis, "How to Assess the Risk of Environmental Disasters" by Christian Genest. In 2019-2020, two lectures were given: "L'espace d'un homme: le projet Grothendieck" by Hervé Nisic, film director, and "Adding Numbers and Shuffling Cards" by Persi Diaconis.



Jean-Marie De Koninck

The Discrete Charm of Geometry

Alexander Bobenko, Technische Universität Berlin

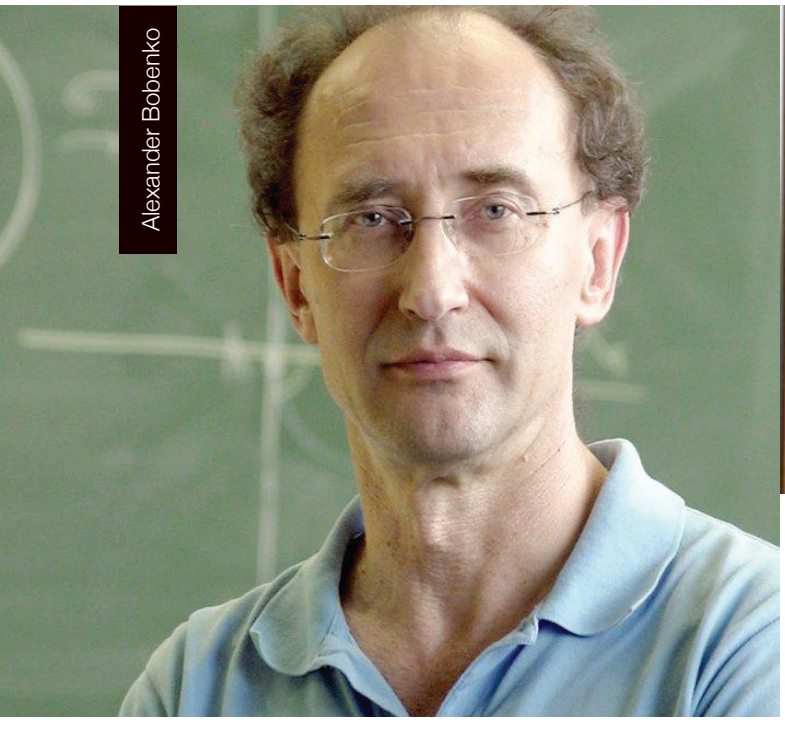
September 12, 2018

Discrete geometric structures (points, lines, triangles, rectangles, polygons, etc.) are ubiquitous in everyday life, ranging from visible sophisticated freeform structures in contemporary architecture to hidden geometric algorithms in computer generated imagery. On the other hand, discrete geometric structures have also proven to be very useful in modeling and approximating continuous shapes (e.g. curves and surfaces) and real processes. This lecture provides a non-technical and pictorial introduction to the foundations of a new branch of mathematics which underpins these real world situations.

By way of simple and concrete examples, we will illustrate the paradigm of so-called structure-preserving discretizations. These include toy spinning tops, elastic rods, smoke rings and vortex lines in fluids, conformal texture mappings in computer graphics, free form glass and steel structures, and animations from Hollywood movies. We will also show excerpts from our new computer-animated movie entitled “Conform”! This film has won Best Experimental Short Film at the Berlin Short Film Festival.

It will be demonstrated that the difference between the continuous and discrete models in geometry and dynamical systems theory is hardly noticeable.

Our aim is to convince you that this new branch of mathematics is both (literally) beautiful and useful.



Alexander Bobenko

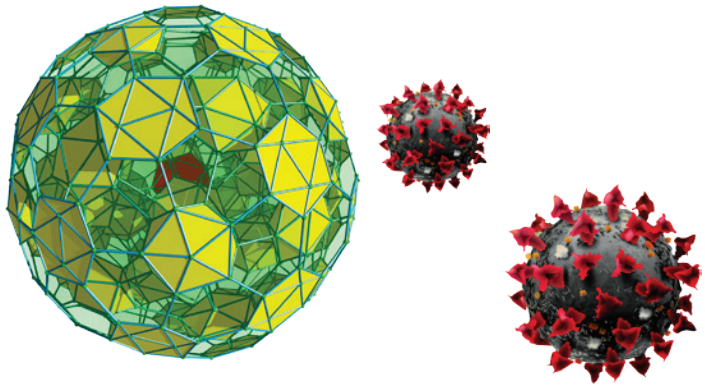
Mina Teicher

The Mathematics of Beauty

Mina Teicher, Bar-Ilan University

January 31, 2019

I shall describe the mathematics behind beauty - man made beauty as well as nature made beauty. I shall argue that beauty is not in the eye of the beholder.



Understanding Animal Movement With a Mathematical Eye

Mark Lewis,
Alberta University

March 14, 2019

Animal movement patterns have long been the subject of mathematical and ecological interest. How do individual behavioral decision rules translate into macroscale patterns of space use such as foraging, patrolling or territories? A mixture of tools including mechanistic models, random walks and other mathematical tools can be used to connect underlying processes to the observed patterns. Here interactions are complex and may involve memory of past events, as well as a cognitive map. I will connect the models closely to detailed biological data, and make applications to a spectrum of different emerging patterns, ranging from territories in Amazonian birds to patrolling in wolves.

How to Assess the Risks of Environmental Disasters

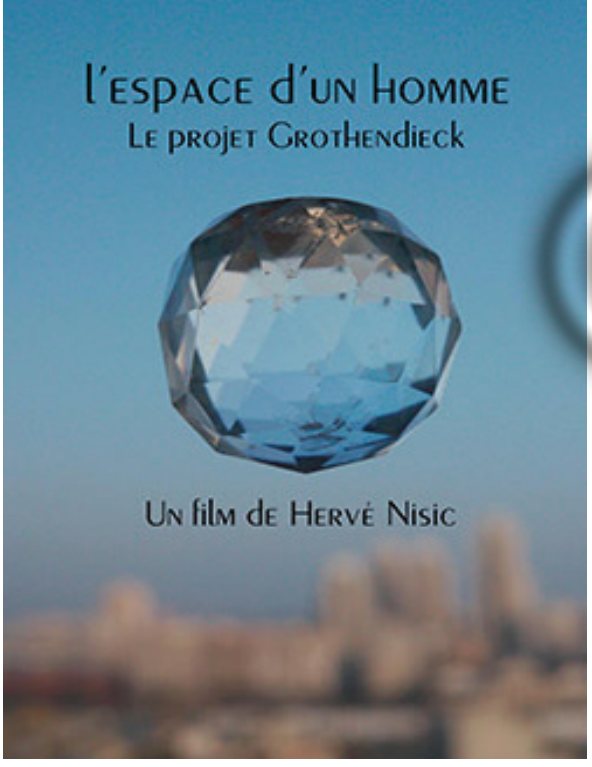
Christian Genest,
University of Montreal

May 10, 2019

In the age of globalization and climate change, it seems that cataclysms of all kinds beset us and threaten our well-being, even our survival: earthquakes, volcanic eruptions, floods, droughts, heat waves, and more. While we cannot predict or prevent these disasters, we can at least prepare for them and protect ourselves against their repercussions. From insurance products to protective structures such as dykes, reservoirs, and dams, the development and implementation of disaster risk mitigation measures requires the estimation of the frequency and intensity of extreme events in time and space. However, the relative rarity of these phenomena poses particular challenges for their modeling using mathematical and statistical tools. We will see how extreme value theory can be used to address this issue and we will mention some recent Canadian applications in property and casualty insurance.

Mark Lewis

Christian Genest



L'espace d'un homme: le projet Grothendieck

Hervé Nisic, film director

10 octobre 2019

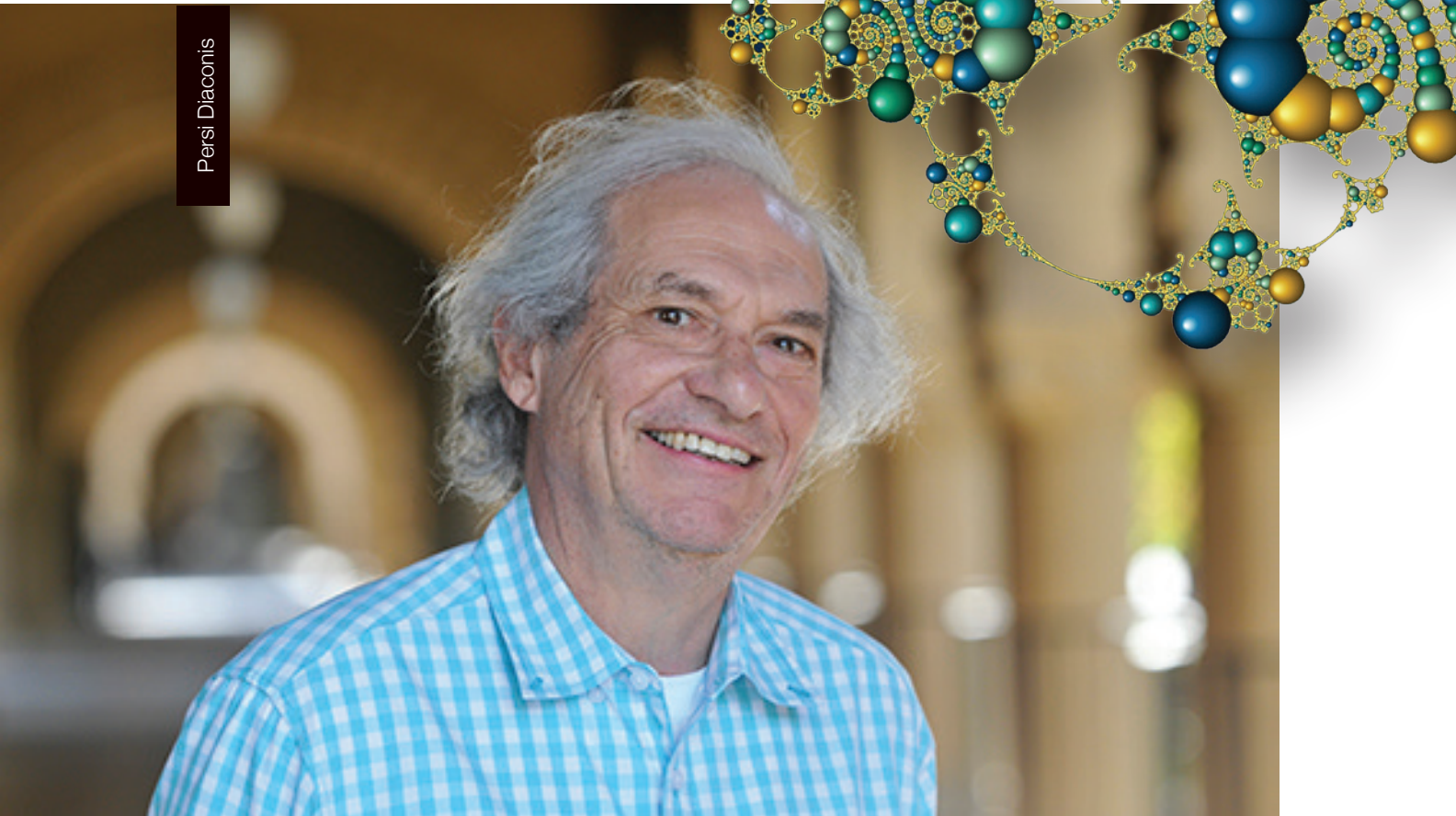
The famous mathematician and environmental activist Alexandre Grothendieck had been living in seclusion for 17 years somewhere in the mountains of southern France in a secret location. The film goes in search of witnesses to his extraordinary life, from his childhood in the French concentration camps to his dazzling burst into the world of mathematics (Fields Medal, Crawford Prize) and then to his radical commitment to political ecology, of which he was one of the initiators in France and Canada. A totally unusual destiny that never ceases to question the responsibility of scientists.

Adding Numbers and Shuffling Cards

Persi Diaconis, Stanford University

27 novembre 2019

When numbers are added in the usual way, 'carries' appear along the way. It is natural to ask 'how do the carries go'? How many are typical; if we just had a carry is it more or less likely that we have a following carry? It turns out that this is very close to the question 'how many times should a deck of cards be shuffled to mix it up' (!).



Persi Diaconis

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 therefore greatly facilitate collaboration between researchers in Québec.

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 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.

Highlights

The lab members have started supervising 9 doctoral theses and hosted 8 postdoctoral researchers. We have organized one summer school and several conferences.

When covid-19 struck our community around mid-March 2020, most seminars came to a sudden halt. Luckily, we all discovered Zoom very quickly and this was the occasion to merge the analysis seminars at Université Laval with the Montreal analysis seminar. Together they became the CRM/Québec/Montréal analysis Zoom seminar (around 40 talks so far). The organizers are Galia Dafni (Concordia), Alexandre Girouard (Laval), Dmitry Jakobson (McGill), Damir Kinzebulatov (Laval) and Iosif Polterovich (U. Montréal). This allowed for a wider participation, for more inter-university discussions and for the invitation of more foreign lecturers, including the best experts in the field. The students could feel the benefits of such wider seminars. The McGill Geometric Analysis Seminar also switched to online activities. This seminar is organized by Pengfei Guan, Valentino Tosatti and Jérôme Vétois.

At about the same time, two new online seminars were launched: The Non-local Operators, Probability and

Singularities seminar, organized by Damir Kinzebulatov (Université Laval) and Karol Szczypkowski (Politechnika Wrocławska); The Spectral geometry in the clouds seminar, organized by Alexandre Girouard (Université Laval) and Jean Lagacé (University of Bristol).

Honors: Christiane Rousseau was named Fellow of the Canadian Mathematical Society (2018); Javad Mashreghi was named Fellow of the Canadian Mathematical Society (2019) and served as President of the Canadian Mathematical Society for two years starting in 2020.

Director

Dmitry Jakobson (McGill)

Regular Members

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

Stephen W. Drury; Dmitry Jakobson; Vojkan Jakšić; Paul Koosis; John A. Toth; Marcin K. Sabok; 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; Damir Kinzebulatov; Javad Mashreghi; Thomas J. Ransford; Jérémie Rostand (Laval)

Tomasz Kaczinski (Sherbrooke)

Dominic Rochon (UQTR)

Vadim Kaimanovich (Ottawa)

Richard Fournier (Dawson College)

Francis H. Clarke (Claude Bernard)

Robert Seiringer (IST Austria)

Associate Members

Octav Cornea; Richard Duncan; Samuel Zaidman (Montréal)

Stephen W. Drury; Kohur Gowrisankara; Pengfei Guan; Niky Kamran; Ivo Klemes (McGill)

John Harnad; Dmitry Korotkin (Concordia)

Guillaume Poliquin (Cégep Ahuntsic)

Nilima Nigam (Simon Fraser)

Yiannis Petridis (University College London)

Dmitry Jakobson

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.

CAMBAM allows its students to sharpen their expertise at all levels by providing exceptional training opportunities in academic and other settings, and to conduct applied research to the highest possible standards and to meet industrial and social needs in clinical and public health.

Highlights

We organized the Joint CAMBAM/NSERC-CREATE in Complex Dynamics Summer School (2018), the annual Symposium in Quantitative Life Science (2018). We offered the support of Leon Glass and Michael Mackey Diamond Symposium (2018). We participated in the 2019 Society for Mathematical Biology (SMB) Annual Meeting (2019).

We partnered with McGill's new Quantitative Life Science (QLS) program to run our most popular seminar series to date (30 talks) during the 2017/18 academic year.

CAMBAM has been a major organizer and supporter of the Cunning Edge Lectures in Science series (CAMBAM members Cook, Mackey and Guichard are part of the Cunning Edge organizing committee). These public lectures, held at the McGill's Redpath Museum, feature some of McGill's most prominent researchers.

Directors

Frédéric Guichard; Erik Cook (until the end of January 2020) et Anmar Khadra (since Februrary 2020) (McGill)

Frédéric Guichard

Regular Members

Jacques Bélair; Morgan Craig; Alain Vinet (Montréal)

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

André Longtin; Frithjof Lutscher (Ottawa)

Associate Members

Fahima Nekka (Montréal)

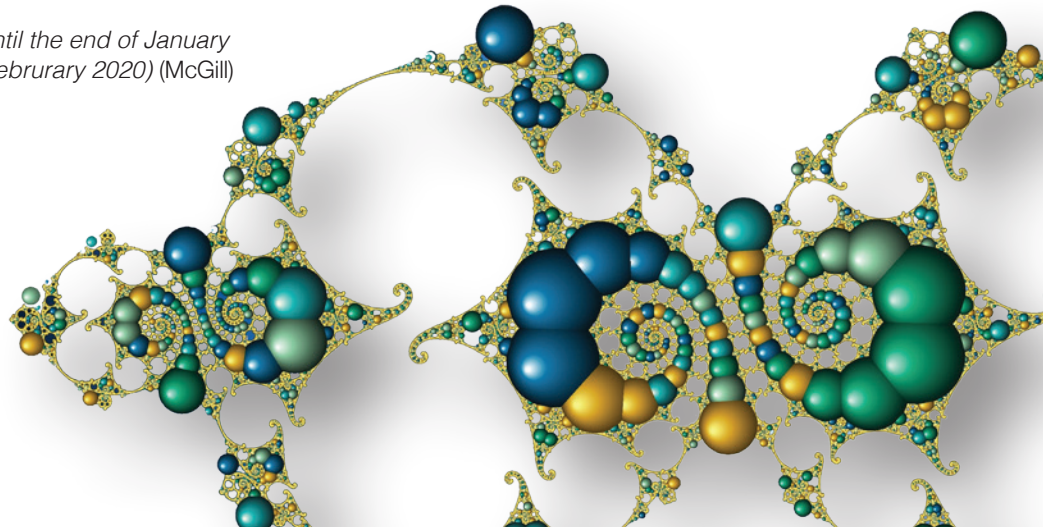
Lea Popovic (Concordia)

Juli Atherton (UQAM)

Michel Loreau; Claire Seizilles de Mazancourt (CNRS)

Moisés Santillán Zerón (Cinvestav)

Vincent Lemaire (Pfizer)



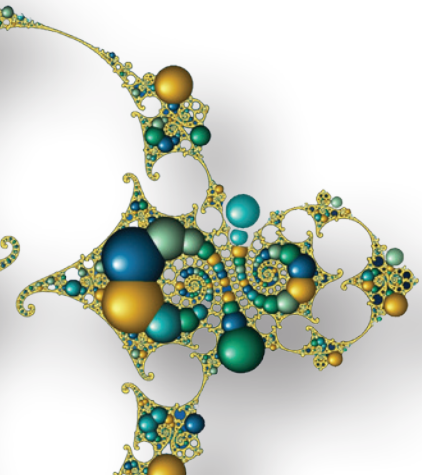
Henri Darmon

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.

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 flavors is particularly well represented in the laboratory.



Highlights

Organized activities

Hugo Chapdelaine; Antonio Lei and Claude Levesque organized the 15th CNTA meeting at Laval in 2018 https://archimede.mat.ulaval.ca/CNTA2018/index_fr.html

Hugo Chapdelaine; Antonio Lei and Claude Levesque organized the Quebec- Maine meeting in 2018 and 2020.

Eyal Goren (with Steve Kudla) organized the twice-yearly Montreal Toronto meeting, when this was not thwarted by the pandemic.

Prizes and honors

Henri Darmon: 2020 Fellow of the Canadian Mathematical Society.

Andrew Granville: 2019 Paul R. Halmos – Lester R. Ford Award, Mathematical Association of America.

Adrian Iovita: Invitation to speak at the 2018 ICM (number theory section)

Maksym Radziwill: Invitation to speak at the 2018 ICM, New Horizons Prize (with Kaisa Matomaki).

Director

Henri Darmon (McGill)

Regular Members

Andrew Granville; Dimitris Koukoulopoulos; Matilde Lalín (Montréal)

Patrick Allen; Henri Darmon; Eyal Z. Goren; John Labute; Michael Lipnowski; Michael Makkai; Maksym Radziwiłł; Peter Russell (McGill)

Chris J. Cummins; Chantal David; Adrian Iovita; Hershy Kisilevsky; John McKay; Giovanni Rosso (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

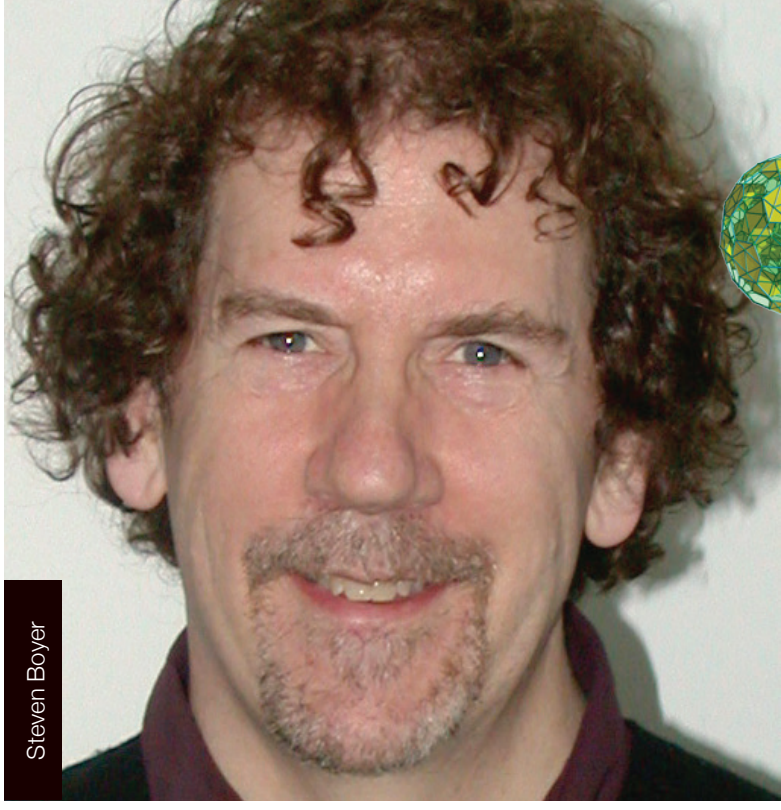
Topology and differential geometry are fundamental disciplines of mathematics whose richness and vitality, evident throughout history, reflect a deep link to our experience of the universe. They are a focal point of modern mathematics and indeed several domains of mathematics have recently shown a strong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

The main themes to be pursued 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 and geometric group theory.

Highlights

Between June 2018 and March 2020, CIRGET members held six workshops, including two to honor its members Steven Boyer and Niky Kamran, three themed programs, and two Summer schools. The autumn of 2019 has been remarkably active with the CRM 50th anniversary program on low-dimensional topology. CIRGET welcomed nine long-term visitors over the semester, among them Ciprian Manolescu (Stanford) as Aisenstadt Chair and in addition five CRM-Simons researchers: Brendan Owens (Glasgow), Lisa Piccirillo (Brandeis), Matthew Stoffregen (MIT), Bulent Tosen (Alabama) and Liam Watson (UBC). During that period, CIRGET organized three weekly seminars: the geometry and topology seminar, an activity intended for all members of the laboratory, as well as two more specialized seminars, one on geometric group theory, and the other on symplectic geometry and topology.

With the confinement, the seminars have become crucial for CIRGET, ensuring that members maintain their regular contact. The Symplectic Seminar adjusted immediately and benefited from its new virtual existence to combine forces with the other universities. CIRGET is now a member of the Symplectic Zoominar, a joint seminary co-organized by CIRGET, the Institute for Advanced Studies and Princeton, Tel Aviv University and Université de Paris-Saclay. All lectures are streamed live and are being recorded so that people can attend at any time. As


Steven Boyer

a worldwide seminar, the talks are usually viewed more than 500 times. The Geometry and Topology seminar and the Geometric Group Theory seminar soon followed the virtual example, with all talks streamed live and recorded, but we continued to hold them locally. While in a typical year each seminar has about 25 speakers, in 2019-20 the Geometry and Topology Seminar and the Symplectic Seminar had 39 and 31 speakers respectively.

Honors: Piotr Przytycki was awarded a 2019-20 AMS Centenary Fellowship, Niky Kamran was elected a Fellow of the Royal Academy of Belgium, and Jacques Hurtubise was appointed an Inaugural Member of the CMS.

Director

Steven Boyer (UQAM)

Regular Members

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

Vestislav Apostolov; Steven Boyer; 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 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. The GIREF members propose general methods that can be used for diverse industrial applications.

Highlights

In 2020, Felix Kwok, a new professor from Laval University joined the GIREF. Prof. Kwok is an internationally recognized authority in the field of domain decomposition and numerical methods.

In collaboration with Prof. Leighton's team from the "Groupe de recherche en épidémiologie des zoonoses et santé publique" (GREZOSP) at the Université de Montréal, the GIREF was awarded one of the highest grants from "Calcul Canada" for the year 2020. A publication in the prestigious "Journal of the Royal Society Interface" was the outcome. It is noteworthy that the model has received the attention of the Canadian Public Health Agency and that there may be a longer-term follow-up.

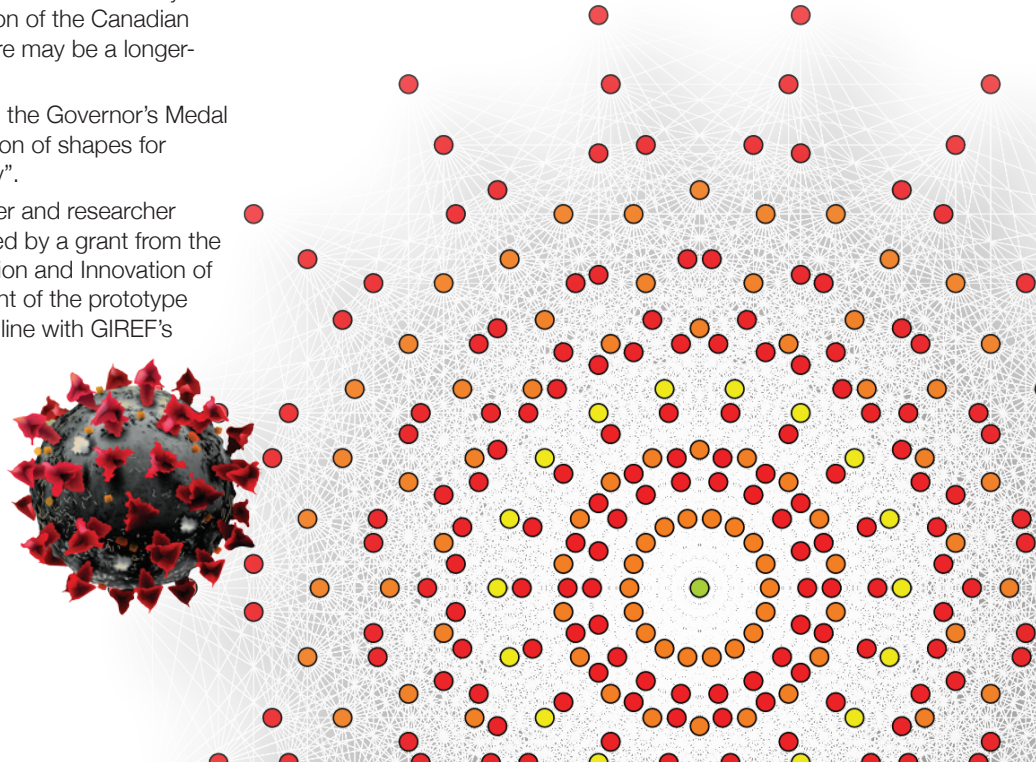
In 2019, Bastien Chaudet received the Governor's Medal for his PhD thesis titled "Optimization of shapes for contact problems in linear elasticity".

In 2019, in order to expand the user and researcher base of MEF++, GIREF is supported by a grant from the Vice-Rectorate of Research, Creation and Innovation of Laval University for the development of the prototype web interface to MEF++. This is in line with GIREF's strategy to enhance its visibility.

The GIREF was approached as a beta tester by Compute Canada to run the Beluga supercomputer, which was under acceptance and validation in the early part of 2019. The challenge was to perform a computation large enough to handle at least 5000 cores. A mesh of a cube consisting of 1,528,823,808 h-axes was generated in 197 seconds, including both reading and writing, on 256 cores spread across 64 Beluga nodes. The final file occupied 627 GB of disk space.

In 2019, a commercial agreement has been made with the French company Dexade. This consultancy company specializes in providing technical and scientific support to businesses in many application fields from food packaging to medical applications. Dexade will use MEF++ as its main simulation tool. In the same year, a new agreement was also concluded with the National Engineering School of Tunis (ENIT). A research group from ENIT, which specializes in rheology and analysis of mechanical behavior laws, will adopt MEF++ as its development and simulation tool for both academic and research needs.

In 2019, Jean Deteix was appointed Director of the GIREF upon the departure of André Fortin, who served



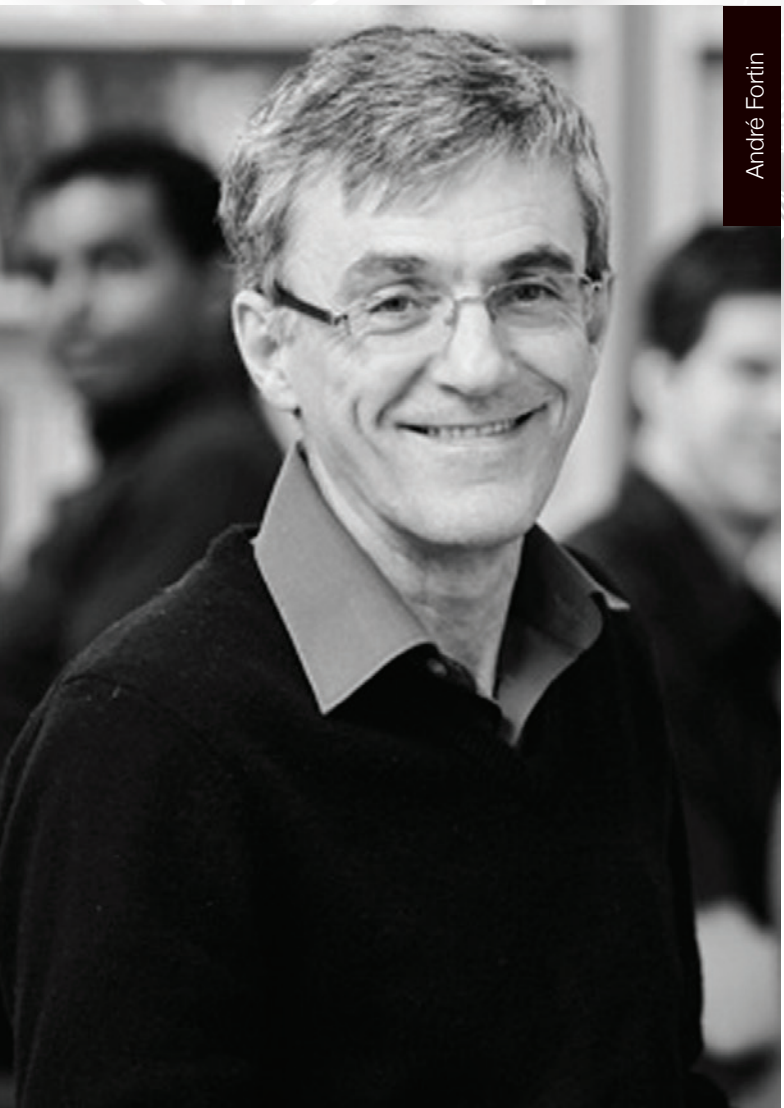
Jean Deteix

as Director for nearly 20 years.

In 2018, Epidemiology. MEF++, the software developed at GIREF, became the computing engine for research based on an epidemiological model of invasion of tick-borne pathogens by Prof. Leighton's team from the Groupe de recherche en épidémiologie des zoonoses et santé publique (GREZOSP) at the Université de Montréal. Directed by O. Tardy, post-doctoral fellow at the Faculty of Veterinary Medicine of the University of Montreal, the collaboration is focusing on the propagation of the Borrelia bacterium, which is responsible for Lyme disease.

In 2018, A. Fortin, J. Deteix and J. Urquiza received NSERC funds in the form of an Industrial Chair (A. Fortin) and two collaborative research and development grants (J. Deteix and J. Urquiza) for a total of approximately $600,000 a year over 5 years.

In 2018, GIREF is a key player in the creation of the Interdisciplinary Centre for Mathematical Modeling at Laval University. CIMMUL covers several disciplines: applied mathematics, statistics, applied probability, scientific computing, actuarial science, geological engineering, physics, biology, medicine, etc. Its member researchers are from six departments at Laval University. It gathers researchers from all backgrounds who share an interest in the diverse forms of Mathematical and Statistical models, their computational implementation and use in the engineering sciences.



André Fortin

Directors

André Garon (Polytechnique Montréal)

André Fortin (Laval)

Jean Deteix (Laval)

Regular Members

Jean Deteix; Nicolas Doyon; André Fortin; Robert Guénette; Khader Khadraoui; René Therrien; José Urquiza (Laval)

Associate Members

Michel Delfour (Montréal)

Alain Cloutier; Marie-Laure Dano; Guy Dumas; Mathieu Olivier (Laval)

Stéphane Étienne; André Garon; François Guibault; Dominique Pelletier (Polytechnique Montréal)

Yves Bourgault (Ottawa)

Mohamed Farhloul, Sophie Léger (Moncton)

Youssef Belhamadia (American University of Sharjah)

LaCIM
Laboratoire de combinatoire et d'informatique mathématique

LaCIM is a research center gathering researchers in mathematics and mathematical computer science working in algebraic combinatorics, discrete mathematics, and the mathematical aspects of computer science. 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.

Highlights

In 2018, F. Bergeron, S. Brlek and C. Hohlweg have organized a monthly special entitled "Algebra and combinatorics at LACIM" in celebration of the 50th anniversary of the CRM, which was attended by 50 researchers from three continents.

Franco Saliola, as a member of LACIM, was one of the ten members of the scientific committee of the 2018 Winter Meeting of the Canadian Mathematical Society (CMS) that was attended by 526 mathematics researchers.

The Tier 1 Canada Research Chair in Algebra, Combinatorics and Mathematical Computing, held by Hugh Thomas, is linked to LACIM.

Director

Christophe Hohlweg (UQAM)

Regular Members

Sylvie Hamel (Montréal)

Anne Bergeron; François Bergeron; Alexandre Blondin Massé; Srečko Brlek; Abdoulaye Baniré Diallo; Christophe Hohlweg; Gilbert Labelle; Vladimir Makarenkov; Christophe Reutenauer; Franco Saliola; Hugh Thomas (UQAM)

Ibrahim Assem; Thomas Brüstle; Shiping Liu (Sherbrooke)

Benoît Larose (Champlain Regional College)

Associate Members

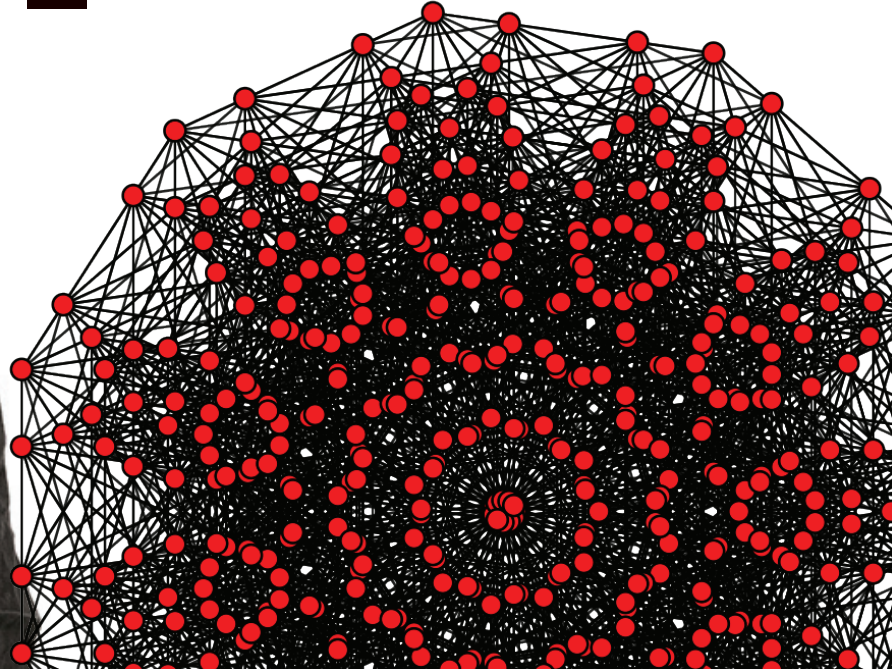
Odile Marcotte (UQAM)

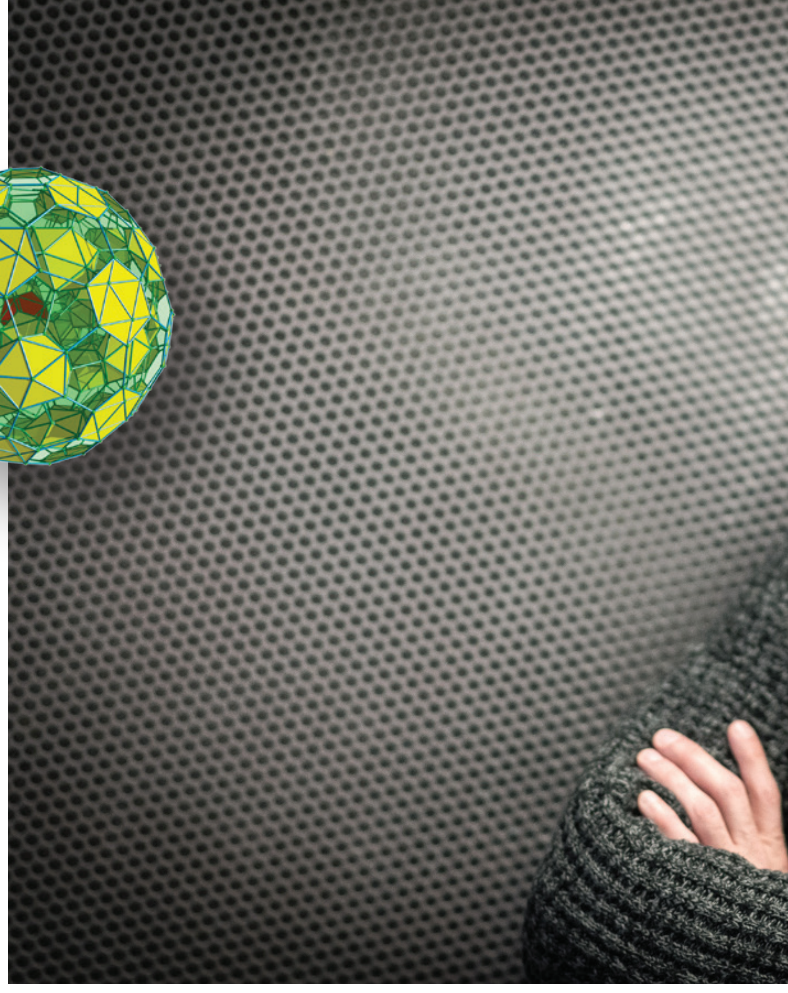
Aïda Ouangraoua (Sherbrooke)

Alain Goupil (UQTR)

Xavier Provençal (Savoie Mont Blanc)

Christophe Hohlweg





Applied Mathematics

The research interests of the laboratory members are quite diverse although there are several 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

Partially due to its more recent additions (Brugiapaglia, Hoheisel, Lessard, Paquette, Yousefzadeh), it represents very current topics such as compressed sensing, machine learning (including deep learning), optimal transport, high-dimensional approximation, variational analysis, and rigorous numerics.

Since June 2018 the lab has hosted over 70 seminar talks, in-person, online or hybrid. With the advent of the global pandemic caused by COVID-19, the seminar became the common public activity of the lab in which Tim Hoheisel and Simone Brugiapaglia (aided by Damien Taggedine) took over the organization from Jean-Philippe Lessard.


Adam Oberman

Honors and prizes: Brugiapaglia, Leslie Fox Prize for Numerical Analysis (2nd place) (2019), Lessard, NSERC Accelerator Supplement Award (2018), Lin, Canada Research Chair -Tier II (2018).

Director

Adam Oberman (McGill)

Regular Members

Jacques Bélair; Robert G. Owens (Montréal)

Peter Bartello; Peter E. Caines; Xiao-Wen Chang; Rustum Choksi; Tim Hoheisel; Anthony R. Humphries; Jean-Philippe Lessard; Jessica Lin; Jean-Christophe Nave; Adam Oberman; Courtney Paquette; Gantumur Tsogtgerel; Adrian Vetta (McGill)

Simone Brugiapaglia; Behrooz Yousefzadeh (Concordia)

André D. Bandrauk (Sherbrooke)

Emmanuel Lorin (Carleton)

Associate Members

Eusebius J. Doedel (Concordia)

Bruce Shepherd (UBC)

Yoshua Bengio

Mila
Montreal Institute for Learning Algorithms

The members of Mila have developed an impressive expertise in deep (discriminating or generative) networks and their applications in computer vision, speech modeling, 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 modeling 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.

Highlights

Summer Schools: Montevideo 2019, Uruguay; AMII-CIFAR DLRL, ML4AI: What Next in DL, 2019, Edmonton; AMII-CIFAR DLRL, Recurrent Nets and Attention for System 2 Processing, 2019, Edmonton; JSALT, Deep Representation Learning, 2019, Montreal; MINOA, 2019, Ischia-Italy; CIFAR Deep Learning and Reinforcement Learning, 2018, Toronto.

Honors and prizes: Bengio, co-winner of the A.M. Turing Award 2018, Killam Prize Winner in Natural Sciences 2019, IEEE CIS Neural Networks Pioneer award 2019, Fellow of the Royal Society of London 2020.

Director

Yoshua Bengio (Montréal)

Regular Members

Yoshua Bengio; Aaron Courville; Simon Lacoste-Julien; Ioannis Mitliagkas; Guillaume Rabusseau; Pascal Vincent (Montréal)

Christopher Pal (Polytechnique Montréal)

Laurent Charlin; Jian Tang (HEC Montréal)

Jackie Cheung; William Hamilton; Joelle Pineau; Doina Precup; Reihaneh Rabbany (McGill)

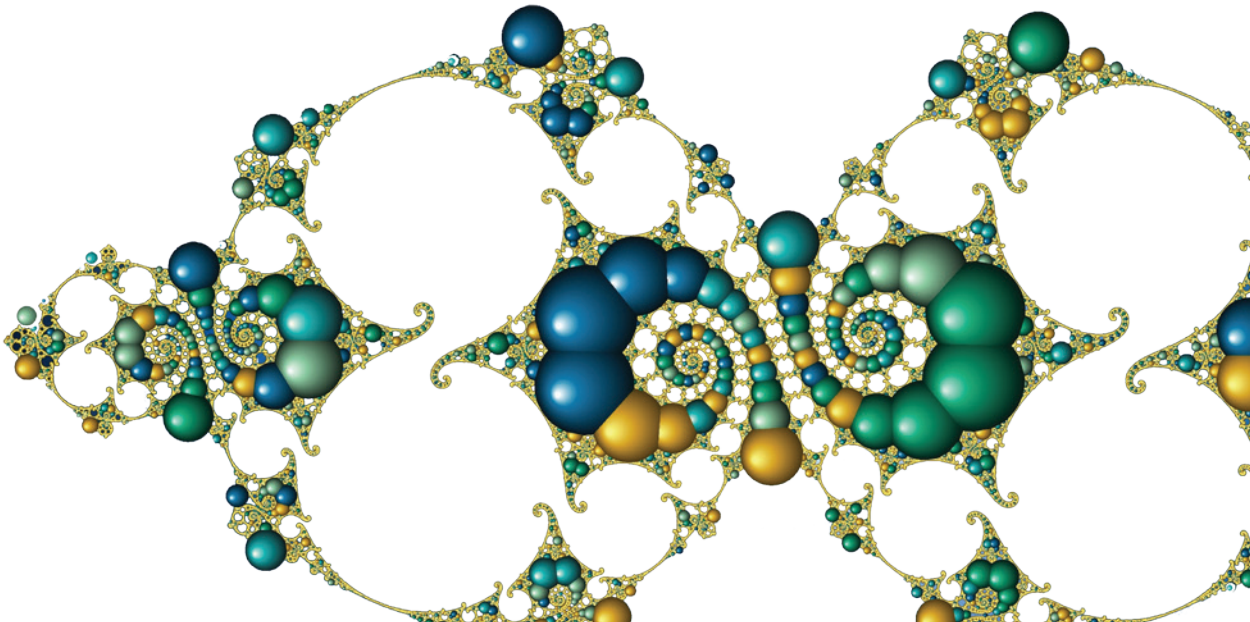
Associate Members

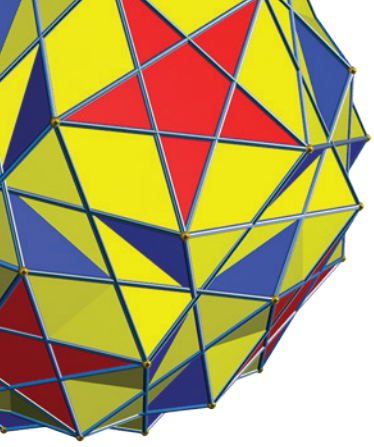
Emma Frejinger; Rex Devon Hjelm; Liam Paull; Alain Tapp (Montréal)

Andrea Lodi (Polytechnique Montréal)

Hugo Larochelle; Nicolas Le Roux (Google)

Geoffrey Gordon (Microsoft Research)





Mathematical Physics

The mathematical physics group is one of the oldest at the CRM. 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.

Highlights

Scientific events organized by Lab members: June 2018 till May 2020 in chronological order: Edmonton, Alberta: Joint Canadian-Asia Pacific Conference on General Relativity and Relativistic Astrophysics; Mini-symposium "Riemann-Hilbert method and its applications in approximation theory and beyond", Ubeda (Spain); International Colloquium on Group Theoretical Methods in Physics 32. Prague Czech Republic; CRM, Montréal Algebraic Methods in Mathematical Physics; Montreal: International Congress of Mathematical Physics; Joint APCTP-Triumf Workshop on Nuclear Theory, APCTP headquarters, Pohang, Korea; Capetown Univ., Double Field Theory: Progress and Applications"; Stella Maris, long Island, Bahamas, 2nd BASIC workshop on solitons, instantons and other topological features; CRM, Faces of integrability; CRM: A Celebration of Geometry, Analysis and Physics; Conference in honor of Niky Kamran's 60th; Lorentz Center workshop, Singularities and Horizons from Black Holes to Cosmology; CIRM, Integrability and Randomness in Mathematical Physics; CRM. 11th International symposium: Quantum Theory and Symmetries; Stella Maris, Bahamas, 3rd BASIC Conference: Theoretical and Mathematical Physics: Solitons, Instantons, Gravitation, Cosmology and other Nonlinear Phenomena; Fields Institute, Toronto, Algebraic Graph Theory and Quantum Information.

John Harnad

Prizes and honors: Luc Vinet, named Fellow of the Royal Society of Canada (FRSC), 2018 and Fellow of the Canadian Mathematical Society, 2019; Yvan Saint-Aubin, named Fellow of the Canadian Mathematical Society, 2018; Pavel Winternitz, Wigner Medal awarded at ICGTMP 32 in Prague, Czech Republic, July 2018; Robert Brandenberger named Honorary Member, National Society of Black Physicists, Nov. 2019; Simon Caron-Huot, Weyl prize awarded at ICGTMP 32 in Prague, Czech Republic, July 2018 and the 2020 New Horizons in Physics Breakthrough prize.

Director

John Harnad (Concordia)

Regular Members

Véronique Hussin; Manu B. Paranjape; Jiří Patera; Yvan Saint-Aubin; Luc Vinet; Pavel Winternitz; William Witczak-Krempa (Montréal)

Robert Brandenberger; Simon Caron-Huot; Keshav Dasgupta; Jacques Hurtubise; Alexander Maloney (McGill)

Marco Bertola; Richard L. Hall; John Harnad; Dmitry Korotkin (Concordia)

Vasilisa Shramchenko (Sherbrooke)

Alfred Michel Grundland (UQTR)

Associate Members

Alexander J. Hariton; François Lalonde (Montréal)

Sarah Harrison; Dmitry Jakobson; Vojkan Jakšić; Niky Kamran; John A. Toth (McGill)

Chris J. Cummins; Alexander Shnirelman (Concordia)

Ferenc Balogh (John Abbott College)

Stéphane Durand (Cégep Édouard-Montpetit)

Robert Conte, Bertrand Eynard (CEA-Saclay)

Jean-Pierre Gazeau; Igor Loutsenko (Paris Diderot)

Alexander R. Its (IUPUI)

Decio Levi (Roma Tre)

Robert Seiringer (IST Austria)

Libor Snobl (Czech Technical University)


Jean-Marc Lina

PhysNum

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

Director

Jean-Marc Lina (ÉTS)

Regular Members

Karim Jerbi; Fahima Nekka (Montréal)
Frédéric Lesage (Polytechnique Montréal)
Jean-Marc Lina (ÉTS)
Habib Benali; Christophe Grova (Concordia)
Maxime Descoteaux (Sherbrooke)
Alain Arnéodo (Laboratoire de physique, ENS Lyon)

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.

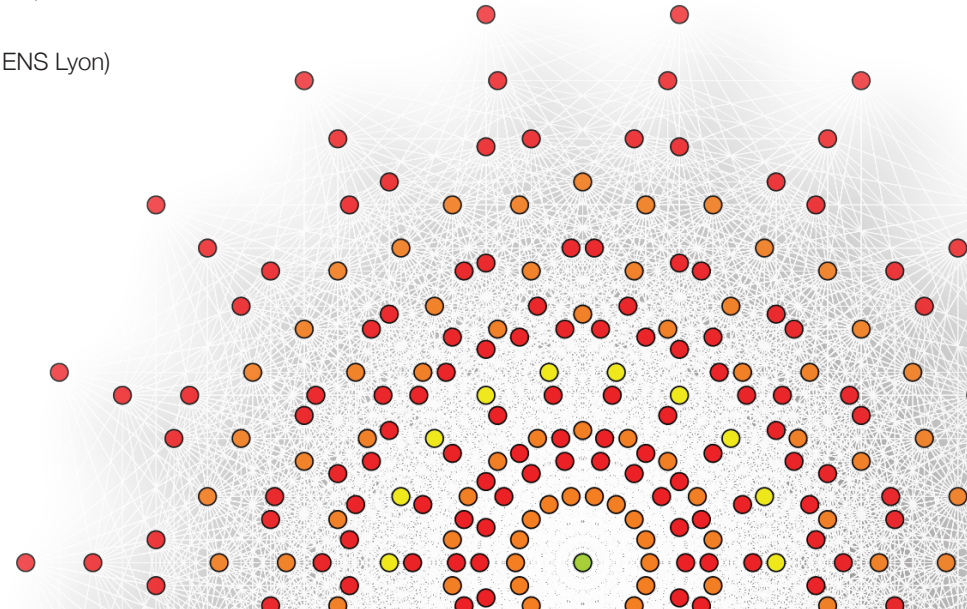
Highlights

In June 2019, lab members Louigi Addario-Berry and Jessica Lin organized the summer graduate school "Dynamics of Random Processes".

In 2020, the lab was one of the first mathematics research groups worldwide to launch graduate training activities called "Online Open Probability School" which took into account the restrictions of the pandemic.

The CRM-PIMS Summer Schools in Probability are a highlight of Canadian probability. Launched by PIMS in 2004, they take the form of two main 4-week courses (often one by a local professor and one by an invited professor) along with a number of keynote addresses and shorter mini-courses. Since 2015, these schools have been jointly organized by the CRM and PIMS.

Honors: Louigi Addario-Berry: Elected Fellow of the Canadian Mathematical Society (2019); Elected Fellow of the Institute for Mathematical Statistics (2020): Luc Devroye: Flajolet Lecture Prize (2018): Wald Memorial Lecturer at the 2018 annual meeting of the Institute for Mathematical Statistics: prix Pierre Simon de Laplace (2019): Jessica Lin: Awarded a Canada Research Chair in partial differential equations and probability (2019).




Hélène Cossette

Director

Alexander Fribergh (Montréal)

Regular Members

Alexander Fribergh; Sabin Lessard (Montréal)

Janosch Ortmann (UQAM)

Louigi Addario-Berry; Linan Chen; Luc Devroye; Jessica Lin; Bruce A. Reed (McGill)

Lea Popovic, Wei Sun; Xiaowen Zhou (Concordia)

Raluca Balan; Aaron Smith (Ottawa)

Donald A. Dawson (Carleton)

Louis-Pierre Arguin (Baruch College, CUNY)

Associate Members

Andrew Granville (Montréal)

Jean-François Coeurjolly (UQAM)

Dmitry Jakobson, Vojkan Jakšić (McGill)

Marco Bertola (Concordia)

Quantact Actuarial and Financial Mathematics Laboratory

The Laboratory members develop and use probabilistic and statistical methods to analyze issues having a financial impact on society.

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 modeling of longevity risk and mortality and its 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

Leadership Chair in Teaching Massive Data Analysis for the Actuary - Intact, Marie-Pier Côté.

Co-Operators Chair in Actuarial Risk Analysis, Jean-Philippe Boucher.

FIN-ML Machine Learning in Finance, Principal Investigator: Manuel Morales; Program: NSERC - Collaborative Research and Training Experience Program (CREATE).

The book Actuarial Finance: Derivatives, Quantitative Models and Risk Management was published in April 2019 by Wiley, in the Applied Mathematics series (592 pages, ISBN: 978-1-119-13702-3).

Chair of the Actuarial Section of the Canadian Statistical Society: Jean-François Renaud: 2016-2019, Hélène Cossette: 2019-2022.

Honors: David Ardia (2019): International Journal of Forecasting, Best paper award 2018-2019; Maciej Augustyniak and Mathieu Boudreault (2018): Best Risks and Rewards Article of 2018 Prize from the Society of Actuaries; Mathieu Boudreault (2018): Canadian Institutes of Actuaries (CIA) Legacy Award of distinction (previously the Silver award), Avant-gardiste 2019, Environment and Climate Change, CIRANO; José Garrido, Canadian Institutes of Actuaries (CIA) Bronze Award (2016), Silver Award (2020).

Director

Hélène Cossette (Laval)

Regular Members

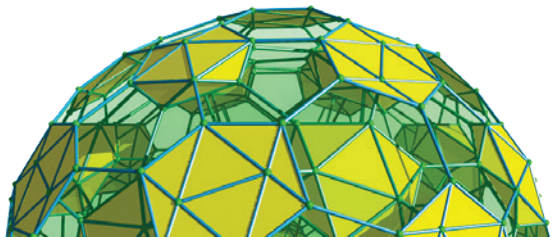
Maciej Augustyniak; Philippe Gagnon; Manuel Morales (Montréal)

Jean-Philippe Boucher; Mathieu Boudreault; Arthur Charpentier; Anne MacKay; Mathieu Pigeon; Jean-François Renaud; Alexandre F. Roch; Clarence Simard (UQAM)

Patrice Gaillardetz; José Garrido; Frédéric Godin; Cody Hyndman; Mélina Mailhot (Concordia)

Hélène Cossette; Marie-Pier Côté; Étienne Marceau; Mathieu Pigeon (Laval)

David Ardia; Chantal Labbé (HEC Montréal)



Éric Marchand

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. The laboratory is formed of the leaders of the Quebec school of statistics, who work on topics such as statistical learning and neural networks, survey sampling, analysis of functional data, statistical analysis of images, dependence structures, Bayesian analysis, analysis of time series and financial data, and resampling methods.

Highlights

The lab supported 4 regular seminars with about 100 presentations: Laval University Statistics Seminar, McGill University Statistics Seminar, Sherbrooke University Statistics Seminar and the Montreal Biostatistics Seminar held at McGill University. It has supported the Colloque R in Quebec City in May 2019 which was organized by members of the lab. organized a fall scientific meeting of the lab at UdeM in November 2018 (3 presentations) He organized a summer scientific meeting of the lab at the University of Sherbrooke in June 2019 (6 presentations); He endorsed the Atlantic Causal Inference Conference (North American) which was held at McGill University in May 2019.

Two consecutive CRM-SSC Prizes: Neslehova (2019), Moodie (2020); one SSC Gold Medal: Remillard (2019); one SSC Award for Impact of Applied and Collaborative Work: Abdous (2019); one A.M. Turing Award: Bengio (2018); one Killam Prize in Natural Sciences: Bengio (2019); one Fellow of the London Royal Society: Bengio (2020); IEEE CIS Neural Networks Pioneer Award: Bengio (2019); one election as Fellow of the Royal Society of Canada: Rivest (2020); one election as IMS Fellow: Neslehova (2020); two elections as ASA Fellow: Stephens (2019), Schmidt (2020); research chair FRQ-IVADO in data science: Labbe (2019); one EBOH Excellence in Mentoring Award: Moodie (2019); one Principal's Prize for Outstanding Emerging Researcher: Moodie (2018); one Carrie M. Derick Award for Graduate Supervision and Teaching: Neslehova (2019); a John L. Synge Award: Genest (2020).

Directors

Éric Marchand (Sherbrooke)

Jean-François Coeurjolly (UQAM)

Regular Members

Jean-François Angers; Mylène Bédard; Yoshua Bengio; Martin Bilodeau; Pierre Duchesne; David Haziza; Christian Léger; Florian Maire; 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; Yi Yang (McGill)

Yogendra P. Chaubey; Arusharka Sen (Concordia)

Belkacem Abdous; Alexandre Bureau; Anne-Sophie Charest; Ting-Huei Chen; Thierry Duchesne; Khader Khadraoui; Lajmi Lakhal Chaieb; Louis-Paul Rivest; Denis Talbot (Laval)

Taoufik Bouezmarni; Félix Camirand Lemyre; Éric Marchand (Sherbrooke)

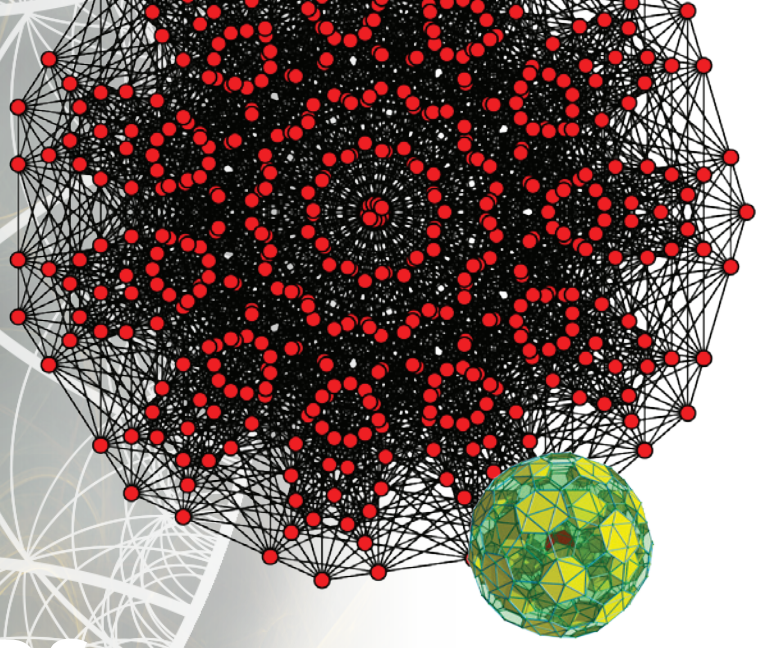
Debbie J. Dupuis, Aurélie Labbe; Bruno Rémillard (HEC Montréal)

Associate Members

Fateh Chebana (INRS-ETE)

Nadia Ghazzali (UQTR)

Vahid Partovi Nia (Polytechnique Montréal)



CRM AWARDS

The CRM confers four prizes each year: the André Aisenstadt Prize awarded by the CRM to a leading young researcher in Canada, the Theoretical Physics Prize awarded jointly by the CRM and the Canadian Association of Physicists (CAP), and the Early Career Award awarded by the CRM and the Statistical Society of Canada (SSC).

The CRM is proud to subscribe to the Université de Montréal's policy on adapting to cultural diversity and is committed to taking into account the diversity and the systemic and individual barriers to access (for example, related to ethnic origin, gender, disability) when selecting the laureates.

The CRM-Fields-PIMS Prize

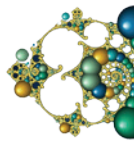
The CRM-Fields-PIMS Prize is Canada's premier award for research achievement in the mathematical sciences. It is awarded jointly by the three Canadian mathematical institutes. The winner receives a cash prize and an invitation to present a lecture at each institute within one year of the announcement of the prize.

The award recognizes outstanding achievement in the mathematical sciences. It was established by the Center for Mathematical Research (CRM) and the Fields Institute as the CRM-Fields Prize in 1994. In 2005, the Pacific Institute for the Mathematical Sciences (PIMS) became an equal partner in the award. It has since been renamed the CRM-Fields-PIMS Prize. The winner is selected by a committee appointed by the three institutes.

The CRM-Fields-PIMS 2020 Prize is awarded to Catherine Sulem

Catherine Sulem, F.R.S.C. and Professor of Mathematics at the University of Toronto, has been awarded the CRM-Fields-PIMS Prize for outstanding achievement in the mathematical sciences. Professor Sulem is the second woman to be awarded the prize since its inception in 1994.

Professor Sulem is being recognized for her numerous and influential contributions to the study of non-linear partial differential equations. Her deep results on the non-linear Schrödinger equation resolved multiple questions that had resisted analysis for years. In particular, her work is central to the understanding of self-focusing singularities to this equation. Her analysis of water waves introduced powerful new probabilistic



ideas to that field. These and other ground-breaking achievements have been acknowledged earlier through her election as a Fellow of both the Royal Society of Canada and the American Mathematical Society, through winning the Krieger-Nelson Prize of the Canadian Mathematical Society and the 2019 Association for Women in Mathematics - Society for Industrial and Applied Mathematics (AWM-SIAM) Sonia Kovalevsky Lecture, and through the award of a Killam Research Fellowship of the Canada Council for the Arts.

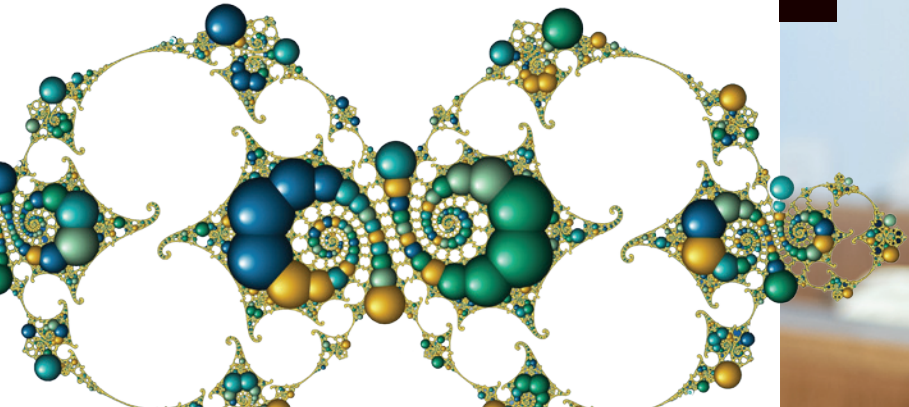
At the CRM, the award conference is coming up.

Catherine Sulem

The CRM-Fields-PIMS 2019 Prize is awarded to Nassif Ghoussoub

Nassif Ghoussoub is professor at UBC. The prize was awarded by a high-level international committee selected by the three institutes. Nassif Ghoussoub has a remarkable record of profound, original and influential contributions to the theory and applications of functional analysis, calculus of variations and partial differential equations. His pioneering work on the solution of the De-Giorgi conjecture, on PDEs of microelectromechanical systems and on the theory of self-dual PDEs have all had a lasting impact on mathematical analysis. Nassif Ghoussoub received his Ph.D. from the Université Pierre et Marie Curie in 1975. Shortly thereafter, he joined the Department of Mathematics at UBC, where he is currently a Distinguished University Professor. His contributions have been recognized by the Coxeter-James, Jeffery-Williams and David Borwein awards of the Canadian Mathematical Society, honorary doctorates from the Université Paris-Dauphine and the University of Victoria, and fellowships in the American Mathematical Society and the Royal Society of Canada. He is an Officer of the Order of Canada.

At CRM, the award conference was held on September 26, 2019. The report of this was published in the CRM newsletter volume 26, issue 1.



Nassif Ghoussoub


Yaniv Plan

The André Aisenstadt Prize

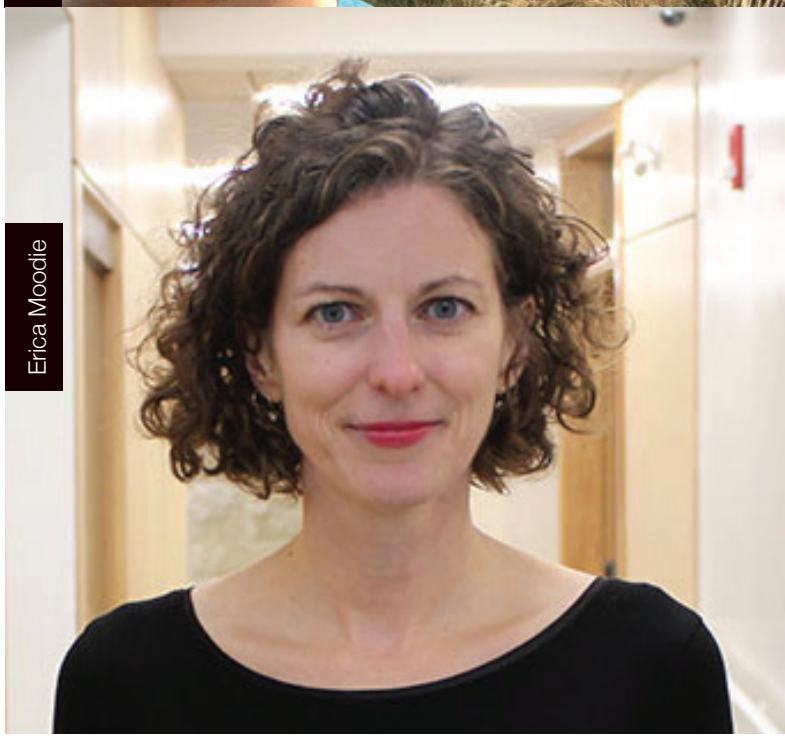
The André Aisenstadt Prize in Mathematics recognizes outstanding research results in pure or applied mathematics by a young Canadian mathematician. The recipient is selected by the CRM International Scientific Committee. Candidates must be Canadian citizens or permanent residents of Canada and have completed their PhD seven years (or less) previously. The recipient is invited to give a lecture at the CRM and to submit an abstract of his/her work for publication in the CRM Bulletin.

The André Aisenstadt 2019 Prize is awarded to Yaniv Plan

Professor Yaniv Plan received his PhD from Caltech in 2011 under the supervision of Emmanuel Candès, a leading figure in the field of information and data mathematics and co-founder of the field of compressed sensing. Between 2011 and 2014, he was an NSF postdoctoral fellow and Hildebrandt Assistant Professor of Mathematics at the University of Michigan, Ann Arbor. In 2014, he joined the Department of Mathematics at UBC where he is currently a tenure-track Assistant Professor and a Tier 2 Canada Research Chair (CRC).

Professor Plan's research focuses on the general area of information mathematics that interacts with various fields, including high-dimensional data analysis, machine learning, harmonic analysis, probability, signal processing, and information theory. Professor Plan's main focus is on compressed sensing and its generalizations such as low rank matrix and tensor recovery. The last decade has seen the construction of an elegant and comprehensive foundation for the theory of compressed sensing. The following is a list of the seminal contributions Professor Plan has already made in this extremely hot area at this early stage of his career: compressed sensing theory; low-rank matrix completion; one-bit compressed sensing; and high-dimensional data analysis.

The award conference was held on November 15, 2019. The summary of its proceedings was published in the CRM newsletter volume 26, issue 1.


Erica Moodie

The CRM-SSC Award

The SSC, founded in 1977, is dedicated to promoting excellence in statistical research and its applications. This prestigious prize, awarded jointly by the SSC and the CRM, is given annually to a Canadian statistician in recognition of outstanding contributions to the discipline during the 15 years following the completion of his or her PhD.

The CRM-SSC 2020 Prize is awarded to Erica Moodie

Erica Moodie, is William Dawson Chair and Associate Professor in the Department of Epidemiology, Biostatistics and Occupational Health at McGill University.

Erica was born and raised in Winnipeg. Her interest in science, which she shares with her sister Zoe, who is also a biostatistician, is rooted in their parents, zoologist Ric Moodie and Patricia F. Moodie, also a biostatistician. After studying mathematics and statistics at the University of Winnipeg (BA, 2000), Erica specialized in epidemiology at the University of Cambridge (MPhil, 2001) and in biostatistics at the University of Washington (MSc, 2004; PhD, 2006). She became an Assistant Professor at McGill in 2006, was promoted to Associate in 2012, and directed the Biostatistics graduate programs from 2012 to 2019.

At the CRM, the award conference is coming up.

Johanna Nešlehová

Jaume Gomis

The CRM-SSC 2019 Prize is awarded to Johanna Nešlehová

This year's mid-career award was given to Johanna Nešlehová, a professor at McGill University, for her fundamental contributions to multivariate analysis, including stochastic dependence modeling and extreme value theory. The award also recognizes her efforts to promote sound risk management practices.

Born in Prague, Johanna Nešlehová is the daughter of Czech painter Pavel Nešleha and art historian Mahulena Nešlehová. She studied mathematics and statistics in the Czech Republic (Univerzita Karlova, 1999) and Germany (Universität Hamburg, 2000; Carl von Ossietzky Universität, PhD, 2004). At ETH Zürich, where she was a postdoctoral fellow and then Heinz-Hopf lecturer, she was introduced to extreme value theory and quantitative risk management by Paul Embrechts. Recruited by McGill in 2009, she has been an Associate since 2012 and currently directs the undergraduate programs in mathematics and statistics there.

The award conference was held on October 4, 2019. The report of the conference was published in the CRM newsletter volume 26, number 1.

The CRM-CAP Award

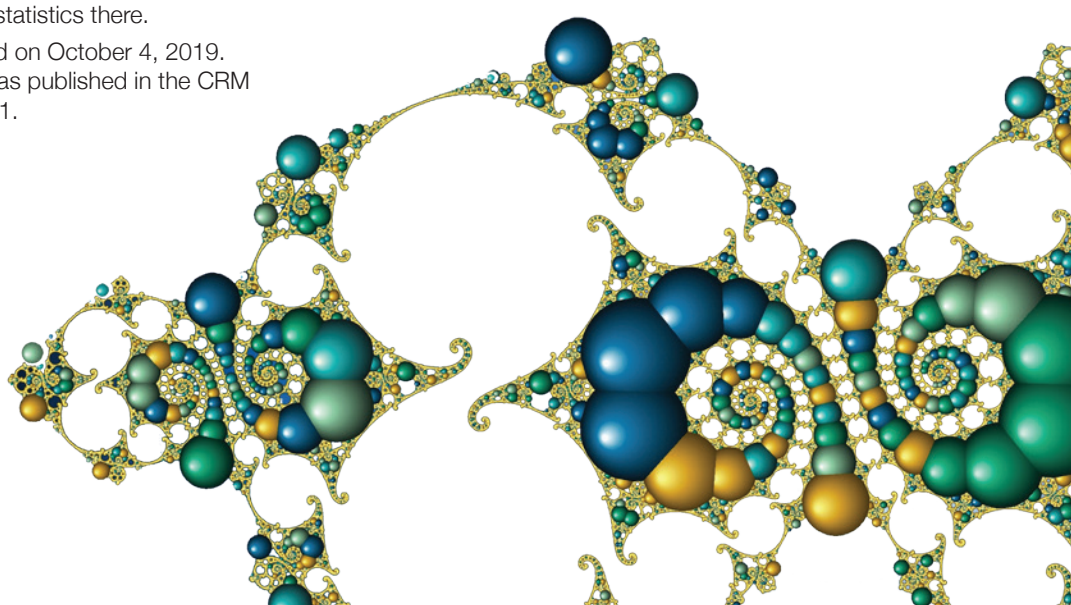
In 1995, on the occasion of the 50th anniversary of the Canadian Association of Physicists (CAP), the CRM and the CAP established a joint award to recognize outstanding achievements in theoretical and mathematical physics.

The CRM-CAP 2019 Prize is awarded to Jaume Gomis

The prize is awarded to Jaume Gomis of the Perimeter Institute for Theoretical Physics for his wide range of important contributions to string theory and strongly coupled gauge theories, including the pioneering use of nonlocal observables, the exact computation of physical quantities in quantum field theory, and the elucidation of the nonperturbative dynamics of gauge theories.

Over the past 15 years, Dr. Gomis has developed new methods for exploring strongly coupled gauge theories by means of non-local variables and by studying these theories in curved space-time. This has allowed him to obtain physical information about these theories and to perform first-of-its-kind exact calculations for key observables in quantum field theory. The computational tools developed by Dr. Gomis in this research have also found applications in various areas of pure mathematics, including enumerative geometry, differential geometry and mirror symmetry. His ongoing work continues to open new frontiers that fuel new discoveries in theoretical and mathematical physics for years to come.

The award conference was held on November 8, 2019. The report of the latter was published in the CRM newsletter volume 26, issue 1.



TRAINING

The mandate of the CRM is to encourage the development of mathematical research at all levels. It therefore contributes to the training of young researchers, the promotion of mathematical research and the development of mathematics education. Almost all of the CRM's activities in this field are organized jointly with the Institut des sciences mathématiques (ISM), which was created in 1991 and has eight partner universities: Bishop's, Concordia, McGill, Université de Montréal, UQÀM, UQTR, Université de Sherbrooke and Université Laval. ISM receives financial support from its partner universities and the Quebec Ministry of Education. The mission of the ISM is to coordinate and harmonize graduate programs in mathematics, to support excellence in training through scholarships and prizes, and to stimulate the interest of young people in the mathematical sciences (in particular through the dissemination of mathematical knowledge to teachers, young people and the general public). The IMS is directed by Professor Alina Stancu of Concordia University.

CRM-ISM Postdoctoral Fellowships 2018-2019

The CRM-ISM Postdoctoral Fellowships program allows promising young researchers to spend the majority of their time on their research at the CRM and partner institutions. The program is highly competitive. Postdoctoral fellows collaborate with established researchers, contribute new ideas, and may organize working groups on cutting-edge topics.

Below is a list of the fellows, with the institution and year they earned their PhD, as well as their supervisor(s) and research area.

Dmitry Faifman (PhD, Tel Aviv, 2015)
Research areas: *Geometry and topology, mathematical analysis.*
Supervisors: Octav Cornea (Université de Montréal), Dmitry Jakobson (McGill), François Lalonde (Université de Montréal), Iosif Polterovich (Université de Montréal), Egor Shelukhin (Université de Montréal) and Alina Stancu (Concordia).

Gabriel Frieden (PhD, University of Michigan, 2018)
Research area: *Combinatorics and mathematical computer science.*
Supervisors: François Bergeron (UQÀM), Christophe Hohlweg (UQÀM), Franco Saliola (UQÀM), Hugh Thomas (UQÀM).

Alexander Mangerel, (PhD, University of Toronto, 2018)
Research area: *Algebra and number theory.*
Supervisors: Andrew Granville (Université de Montréal), Dimitris Koukoulopoulous (Université de Montréal) and Maksym Radziwill (McGill).

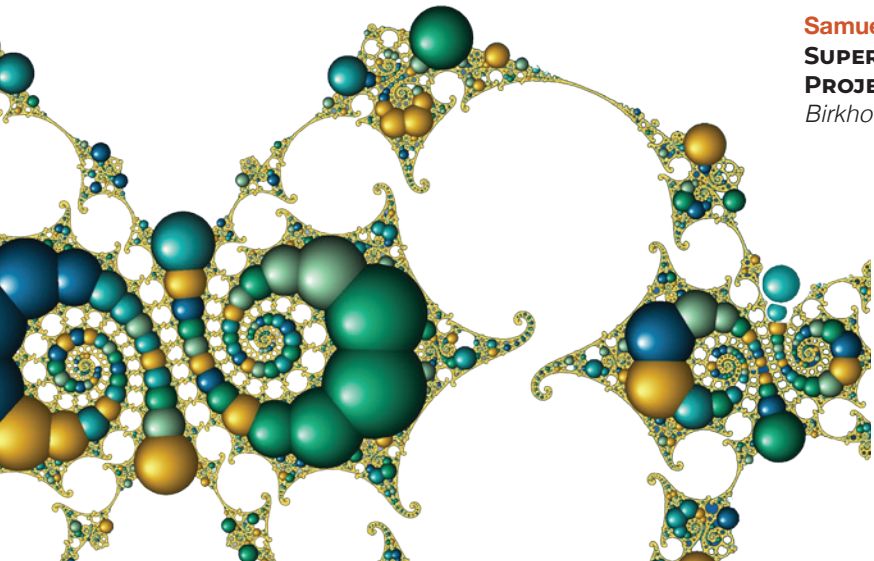
Wanlin Li (Ph.D., University of Wisconsin-Madison, 2019)
Research area: *Algebra and number theory.*
Supervisors: Chantal David (Concordia), Andrew Granville (Université de Montréal), Matilde Lalin (Université de Montréal).

Steven Melczer (Ph.D., University of Waterloo, 2017)
Research area: *Combinatorics and mathematical computer science.*
Supervisors: François Bergeron (UQÀM) and Hugh Thomas (UQÀM)

Liangming Shen (PhD, Princeton, 2015)
Research area: *Analytical geometry.*
Supervisors: Vestislav Apostolov (UQÀM), Steven Lu (UQÀM) and Frédéric Rochon (UQÀM).

Aled Walker (Ph.D., Oxford, 2018)
Research area: *Algebra and number theory.*
Supervisors: Andrew Granville (Montreal) and Dimitris Koukoulopoulos (Montreal).

Jun Zhang (Ph.D., University of Georgia, 2016)
Research area: *Geometry and topology.*
Supervisors: Octav Cornea (Montreal), François Lalonde (Montreal) and Egor Shelukhin (Montreal).



CRM-ISM Undergraduate Summer Fellowships

In collaboration with the CRM and ISM faculty members, summer fellowships are offered to undergraduate students who wish to do a research internship in the mathematical sciences in order to eventually pursue graduate studies. Summer fellows are normally supervised by postdoctoral fellows.

Below is the list of fellows (in alphabetical order) for the summers of 2018 and 2019.

Jacksyn Bakeburg (McGill)
Young Investigator Supervisor: Haining Wang
Senior Supervisor: Henri Darmon
Project: *Class Field Theory*

Antoine Beaudet (Université de Montréal)
Young researcher supervisors:
Félix Desrochers-Guérin and Biji Wong
Senior Supervisor: Olivier Collin
Project: *Category-theoretic methods for understanding topological objects*

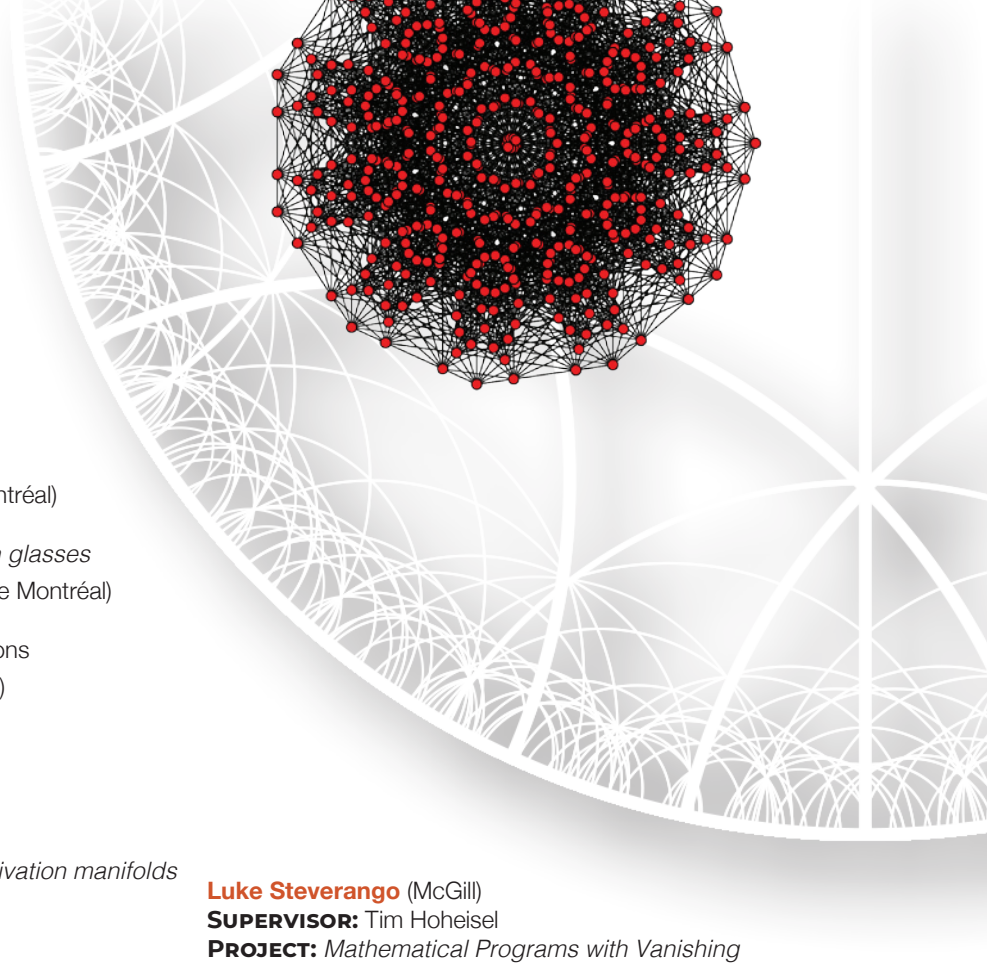
Jonathan Boretsky (McGill)
Young researcher supervisors:
Erfan Nazari Zahraei Motlagh
Senior Supervisor: Niky Kamran
Project: *Spin Chains*

Ludovick Bouthat (Laval)
Young supervising researcher:
Maëva Ostermann
Senior supervisor: Thomas Ransford
Project: *The Sendov conjecture*

Emily Carrick (McGill)
Supervising junior researcher:
Alexander Garver
Senior Supervisor: Hugh Thomas
Project: *Exceptional Sequences*

Jonathan Classen-Howes (McGill)
Supervisor: Simon Caron-Huot
Project: *From Integrable Spin Chains to the Strong Interactions*

Samuel Desroches (Université de Montréal)
Supervisor: Egor Shelukhin
Project: *Review of existing proofs of the Poincaré-Birkhoff fixed point theorem*



Raphaëlle Élément (Université de Montréal)
Supervisor: Alexander Fribergh
Project: *Random matrices and spin glasses*

Aude Forcione Lambert (Université de Montréal)
Supervisor: Guillaume Lajoie
Project: Recurrent networks of neurons

Victor Geadah (Université de Montréal)
Supervisor: Guillaume Lajoie
Project: *Networks of neurons*

Stefan Horoi (Université de Montréal)
Supervisor: Guy Wolf
Co-supervisor: Guillaume Lajoie
Project: *Geometric attributes of activation manifolds in recurrent neural networks*

Patricia Lamirande (Laval)
Young researcher supervisor: Aymeric Gauvin Maury
Senior supervisor: André Fortin
Project: *Convection-diffusion-reaction equations in biology*

Élodie Lapointe (University of Sherbrooke)
Young researcher supervisor: Souheila Hassoun
Senior Supervisor: Thomas Brüstle
Project: *Stability condition on extriangulated categories*

Léo Lortie (Laval University)
Young supervising researcher: Frédéric Morneau-Guérin
Senior Supervisor: Thomas Ransford
Project: *The Souslin problem*

Joshua Sandor (McGill University)
Supervisor: Simon Caron-Huot
Project: *Chaos and Harmonic Polylogarithms in Conformal Fishnet Theory*

Luke Steverango (McGill)
Supervisor: Tim Hoheisel
Project: *Mathematical Programs with Vanishing Constraints*

Youri Tamitegama (McGill)
Supervising junior researcher: Niko Laaksonen
Senior Supervisor: Dmitry Jakobson
Project: *Graph embeddings by heat kernel*

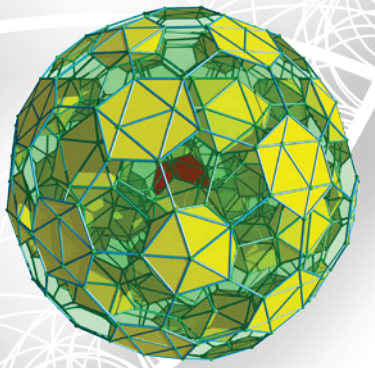
Mathieu Trudelle (Laval)
Supervisor: Antonio Lei
Project: *Observing the properties of p-adic numbers*

Christopher Turley (Concordia)
Supervising junior researcher: Almaz Butaev
Senior Supervisor: Pawel Gora
Project: *Fractal Theory and Dimension Theory*

Scientific Activities

The CRM actively participates in the activities of the 24 hours of science: The themes addressed were, in 2018, «Maths in motion» and, in 2019, «The Earth of tomorrow: can maths help?»

The CRM has regularly offered its support to various student colloquia in mathematics and statistics. It has also offered support to the Planet A Colloquium in 2019. This colloquium is an international collaboration initiative launched by the CNRS International Joint Units (UMI) network in North America. This initiative aims to bring together actors from research, industry and civil society, with complementary expertise and skills, wishing to work together to provide answers to the sustainable development goals set by the UN and to the objectives arising from the Paris Agreement on climate change.



Promotion of Mathematical Sciences

Christiane Rousseau has led UNESCO to establish the International Mathematical Day in 2019 of Mathematics to be held annually on March 14.

The CRM recently established the Robert Langlands Endowment Fund. This fund is intended to finance activities that promote the use of the French language. These activities include training and research in mathematics in Quebec and Canada.

The journal **Accromαth** is produced by the ISM. The CRM pays a part of its production costs. It is published twice a year and distributed free of charge to all high schools and CEGEPs in Quebec. Its purpose is to provide lively, relevant and current material to the teaching staff of these institutions. This magazine has won several awards for both its content and its graphic design.

The CRM and the ISM financially support the Sciences et mathématiques en action program (set up by Professor Jean-Marie De Koninck) as well as the Association québécoise des jeux mathématiques.

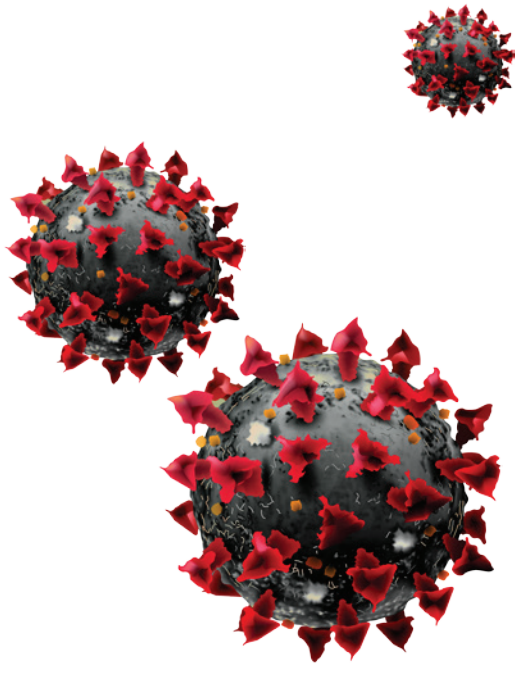
Supervision of Students

CRM researchers supervise a very large number of graduate students. Information on the number of supervised students can be found in the section on laboratories.

Supervision of preschool and primary school teachers and parents-children Workshops.

During the 2019-2020 school year, the «**EnAvantMath!**» national initiative provided support to teachers in a primary school in the Pointe-de-l'Île School Board. In this regard, teachers at the elementary school, through a PLC (Professional Learning Community), re-examined the mathematics curriculum. Emphasis was given to the problems that students may encounter, especially in solving mathematical problems, and to the support that teachers can afford them. In addition, a pedagogical day that brought all the teachers at this school together was devoted to the teaching of arithmetic, particularly when moving from the preschool to their primary school, and from one cycle to the following.

During the 2018-2019 school year, parent-child workshops based on traditional games from several cultures and epochs in support of learning mathematics were provided in 12 classes of a Parc-Extension neighborhood school. The parent-child sessions of play were followed by a discussion with parents on the relationship between Maths and the game, and on the questions to be asked to the children to ensure that the game remains more than just a play. At the end of the workshop, all pupils in the class were provided with the game board and the materials they needed to play at home. About 200 kids attended to workshops with an average of 6 to 9 parents for every group. These activities have been taken up with two new Workshops in 2019-2020. This time they are being organized in thirty classes of the same school! Around 600 pupils and many parents were able to attend these two workshops.



EN AVANT MATH!

PROJECT

Quebec stands out across Canada and internationally for its mathematical culture and its many poles and academic institutions of excellence, especially in the field of artificial intelligence and technological innovation. Quebec's economic potential is based on its human capital and the needs to develop high skills in mathematics are enormous and urgent: thus, Quebec must expand the pool of curious young people in all fields related to technological advancement: as Mathematics knowledge and skills exert a power and a determining role in the most strategic domains!

This document is an overview report summarizing the efforts to implement one of the Quebec projects in the field of Mathematics and some of the achievements fulfilled. It is about "**EnAvantMath!**"[1].

"**EnAvantMath!**", a national initiative launched by the "Centre de Recherches Mathématiques" (CRM) and the "Centre Interuniversitaire de Recherche en Analyse des organisations" (CIRANO), has been awarded a one million dollar grant by the Quebec Ministry of Finance for the "Establishment of a strategy to foster the development of a highly qualified workforce in applied mathematics for advanced fields". For the director of the CRM, Mr. Luc Vinet, the "**EnAvantMath!**" program will only be a success "if it succeeds in generating a movement to radically increase numeracy in Quebec. To do this, we want this project to be inclusive and unifying. It is essential that all levels of education take part"[2].

"**EnAvantMath!**" is also an initiative to undertake a national strategy to counter the "social filter", "siphon", and " mathematic gateway" effect on all citizens: children, young people, and adults. Mathematics has become determinant of inclusion / exclusion, empowerment / disempowerment in all sectors and for all domains: school, university, vocational and technical training, employment, and the labor market. The lack of mastery of mathematical skills is a source of frustration and anxiety for children and young people, which often leads to them dropping out of mathematics and science even before they drop out of school! At this regard, the "**EnAvantMath!**" initiative aims to increase and diversify the opportunities and spaces for promoting and raising awareness of the importance of mathematics and numeracy in all contexts (school, academic, professional, and civic) while highlighting their growing place in the qualifications for the careers and professions of the world of tomorrow.

The strategy adopted by the CRM-CIRANO team for the "**EnAvantMath!**" initiative has two main components:

- Producing studies that provide evidence to fuel reflection. For example, several studies are underway concerning the alignment between the mathematical concepts of ministerial programs and the mathematical concepts used in STEM (science, technology, engineering and mathematics) jobs, the determinants of the choice of training in mathematics at university and identifying skills in demand in STEM in the labor market.
- Implementing various field activities to promote mathematics.

We summarize the essentials of the actions carried out by the CRM-CIRANO team since the official launch of the project until June 2020.

1 *https://enavantmath.org/: Une initiative nationale pour promouvoir les mathématiques.*

2 *https://nouvelles.umontreal.ca/article/2019/12/03/un-million-pour-donner-le-gout-des-mathematiques-aux-quebecois/: Un million pour donner le goût des mathématiques aux Québécois.*

Activities associated with the official launch of the National "EnAvantMath!" Initiative!

On November 28, 2019, the official announcement of the launch of the "**EnAvantMath!**" takes place in a public school in Montreal, École Barclay, located in the Parc Extension district, in the presence of Marc Sirois, Associate Deputy Minister of the Ministry of Finance and all the members of the CIRANO-CRM project "**EnAvantMath!**" (photo 1).

The announcement of "**EnAvantMath!**" was also the opportunity for a hundred students of the Barclay school to attend the play "Count on me" (photo 2), an initiative of Jean-Marie De Koninck, Professor Emeritus and Founder of Sciences and Mathematics in Action (SMAC), who took advantage of his speech to stress the importance of investing in Quebec's underprivileged areas.

2

Presentation of the play ***"Compte sur moi"*** *to the students of Barclay school,the day of the anouncement of the project.*

1

From left to right: *Claude Monmarquette, chercheur et Fellow chez CIRANO; Luc Castonguay, Directeur principal au développement économique au ministère des Finances du Québec; Nathalie de Marcellis-Warin, présidente-directrice générale du CIRANO; Luc Vinet directeur du CRM; Louise Poirier directrice adjointe au CRM; Geneviève Dufour, directrice de projets au CIRANO et Marc Sirois, Sous-ministre associé au ministère des Finances.*

The official announcement of the "**EnAvantMath!**" Initiative was spread to the general public through the development of a website for the initiative (https://enavantmath.org/) and to several interviews and communications conducted by Luc Vinet and Louise Poirier (https://nouvelles.umontreal.ca/article/2019/12/03/un-million-pour-donner-le-gout-des-mathematiques-aux-quebecois/).

The "**EnAvantMath!**" Website also enables the dissemination of several resources related to the promotion of numeracy and mathematics to the general public, as is the case with traditional games for teaching mathematics at the primary level and of which 11 games are already put online (site: https://enavantmath.org/), section: discover traditional games. Some of these games were the subject of parent-child workshops (photo 3).

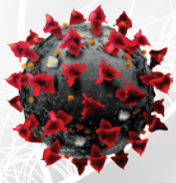
Workshop on traditional games, Barclay school , Montreal

3

On 17 of December 2019, in a perspective of collaboration and partnership with UNESCO, a meeting with the Secretary General of the Canadian Commission for UNESCO, Stéphane Goupil, was held at the CRM offices. The UNESCO Representative stressed the importance of the "**EnAvantMath!**" Initiative for UNESCO's mandate in the presence of Christiane Rousseau, who made March 14 International Mathematics Day (photo 4).

From left to right: *Josée Leclerc, conseillère principale en communication (CRM) ; Louise Poirier, directrice adjointe (CRM) ; Christiane Rousseau, professeure titulaire (CRM, UdeM); Stéphane Goupil, Secrétaire générale de la commission canadienne pour l'Unesco, Laïla Oubenaïssa, coordinatrice* **EnAvantMath!** *et chargée de projets, projet numératie (CRM).*

4



Studies/analysis carried out by the CRM-CIRANO team 2019-2020

CRM projects

- Training programs for elementary school teachers in Quebec for teaching mathematics as well as the tools made available to them (Louise Poirier).
- International and Canadian experiences in the field of numeracy (Laïla Oubenaïssa & Louise Poirier).
- Portraying Quebec students in mathematical sciences (Laïla Oubenaïssa & Louise Poirier).
- Numeracy: a complex concept and an evolving frame of reference (Laïla Oubenaïssa & Louise Poirier).

CIRANO projects

- The determinants of the choice of university discipline. Why choose mathematics training? (Claude Montmarquette).
- Teaching Mathematics in Quebec High Schools: Alignment between Teachers, Mathematical Concepts in Ministerial curriculum and Mathematical Concepts Used in STEM Jobs (Annie Savard).
- What Skills are in demand in the STEM industry, what are the unmet needs, and can corporate training meet these needs? (Benoit Dostie).
- The private and social return of university education in Quebec in 2015: focus on mathematics (Francois Vaillancourt and Claude Monmarquette).
- Numeracy and the labor market (Raquel Fonseca and Catherine Haeck).

Activities on the ground

It consists of setting up activities to promote mathematical sciences offered in the field to various audiences (under the responsibility of Louise Poirier (CRM, University of Montreal) and Frédéric Gourdeau (Laval University)

TOTAL BUDGET: $150,000

SELECTION COMMITTEE CHAIRED BY:
Frédéric Gourdeau and Louise Poirier

From the first call, 12 projects were selected[3]

The list of selected projects for 2020-2021

Les maths partout autour de nous

VALÉRIE BILODEAU,
Les Scientifines Executive Director

OBJECTIVE: *Develop* 20 educational workshops that promote the acquisition of mathematical knowledge in a fun and creative way. These workshops will be integrated into our regular programming, in addition to being offered to young people in our schools and partner organizations, so that over 1,000 young people will benefit.

TARGET AGE GROUP: Elementary school students

LOCATION: Montreal, disadvantaged neighborhoods

Modéliser et simuler pour comprendre le monde

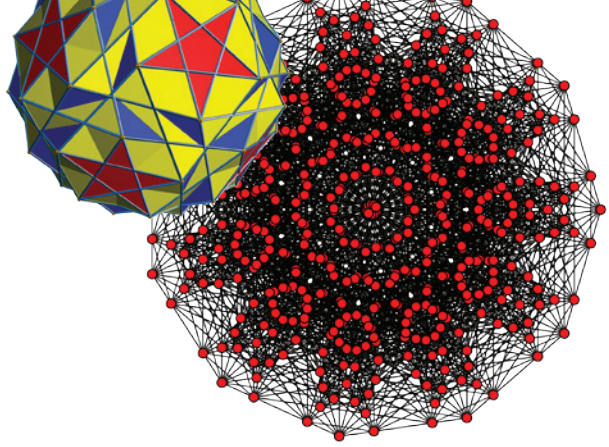
FRANCE CARON, University of Montreal

OBJECTIVE: *Validate* the contribution of mathematical modeling in the fields of health and the environment. Workshops will be offered to explore one or other of these themes from the perspective of dynamic systems, to learn to build and use models, and to establish links with the mathematics taught. These workshops will introduce students to mathematical modeling, help them to think critically about the results they generate, and give them a new perspective on the use of mathematics in these areas.

TARGET AGE GROUP: College and university, possibly high school

LOCATION: Workshops in Quebec and website

3 *Detailed project summaries can be found on the "**EnAvantMath!**" website: https://enavantmath.org/ under Call for the activities on the ground, 2020-2021.*



Assurer la pérennité de Math en jeu

Jean-Marie De Konninck, University of Laval

Objectives: *Consolidate* and *update* Math in Play, an interactive multimedia game available for free on the Internet (over 28,000 registered users, mainly young people) so that thousands of young people can continue to use this free educational tool. Our goal is to reach more young people, while increasing our "mathematical footprint" in each of them.

Target age group: Primary and secondary
Location: Website

Activités mathématiques ludiques gratuites

Jean-Marie De Konninck, University of Laval

Objective: *Offer* a variety of activities including mathematical lectures, interactive science plays, games and workshops, reaching nearly 65,000 Canadian elementary and high school students each year. Our goal is to reach more young people, while increasing our "mathematical footprint" in each of them.

Target age group: Primary and secondary
Location: All regions of Quebec

Déploiement de la ressource pédagogique Code tes maths

Mélisande Fortin-Boisvert,
Collège de Maisonneuve

Objectives: *Consolidate* and *enrich* the "Code tes maths" educational resource to ensure the multiplication of activities in other regions of Quebec. Collège de Maisonneuve has developed programming workshops in collaboration with four Montreal high schools. The workshops are hosted on an educational web platform and are led by students in the classrooms. This pedagogical resource reinforces learning in mathematics at the secondary level, while developing students' digital skills.

Target age group: Secondary
Location: Workshops in Quebec and website

Cercle mathématique ludique de l'AQJM et Semaine des maths 2020

Frédéric Gourdeau, University of Laval

Objective: *Allow* the AQJM to continue its work while embarking on a new project of playful and participatory mathematics, by offering during the 2020-2021 school year meetings of the Playful Mathematics Circle to young people in grades 4 to 6 of primary school once a month, each session being offered three times (on different days, in different places and/or to different clients). One of these monthly sessions will be offered with a partner working in an underprivileged area.

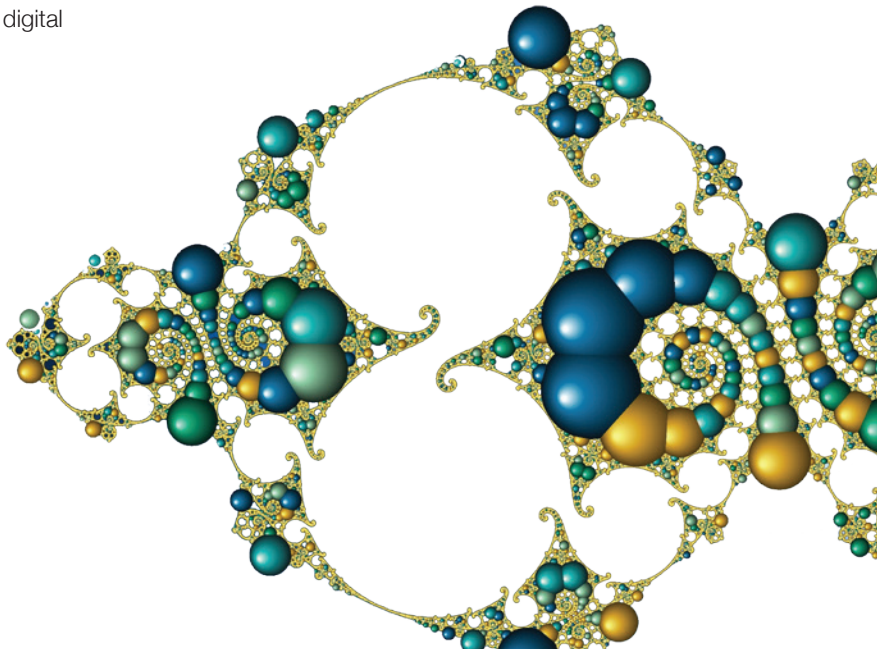
Target age group: Primary and possibly secondary
Location: All regions of Quebec

Les cercles mathématiques du Québec

Alexandra Haedrich,
Institut des Sciences Mathématiques (ISM)

Objective: *Ensure* the sustainability of the two mathematics circles in Quebec: one in Montreal led by Ildiko Pelczer at Concordia University, and the second in Sherbrooke led by Vasilisa Shramchenko, by training and paying student leaders who will be able to mentor more students and, in the long term, spread the initiative more widely. To encourage the creation of new circles, ISM will increase the visibility of the program and create a central website dedicated to circles.

Target age group: Primary and secondary (ages 10-18)
Location: Montreal and Sherbrooke and website



Situations mathématiques à caractère ludique pour intervenir en orthopédagogie

Virginie Houle, University of Quebec in Montreal

Objective: *Implement*, in a special needs context, mathematical situations of a playful nature in order to promote cognitive engagement and learning of primary school students with mathematical difficulties. Specialists in "orthodidactic" mathematics from UQAM will accompany CSMB professionals in the appropriation and experimentation of original situations resulting from research on the teaching-learning of multiplicative structures (multiplication and division).

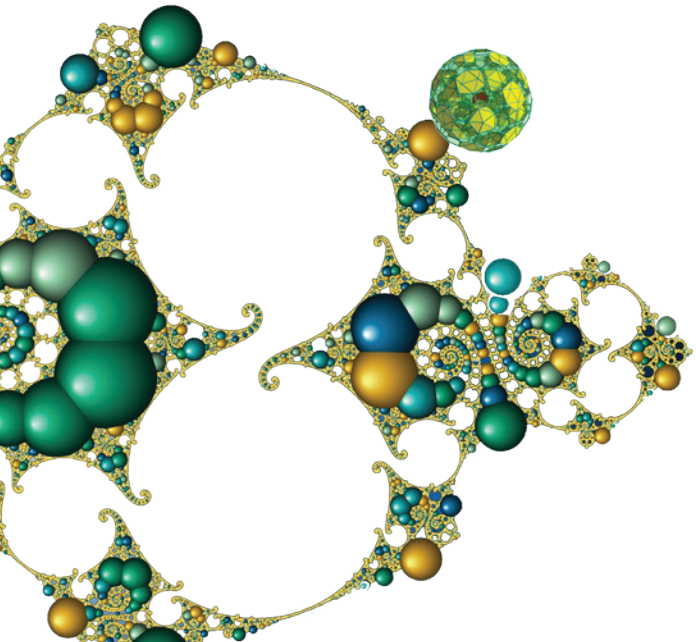
Target age group: Primary, orthopedagogy
Location: Montreal, Commission scolaire Marguerite-Bourgeois

AcceSciences, volet mathématique du projet *Pour un Montréal Scientifique*

Hélène Mathieu,
Regroupement des cégeps de Montréal

Objectives: *Consolidate* and *offer* the activities of the mathematics component of the "*Pour un Montréal scientifique*" project to 1,800 new students and 70 teachers from 12 elementary schools in disadvantaged neighborhoods; in six Montreal boroughs for the year 2020-2021. The "*Pour un Montréal scientifique*" project consists of accompanying elementary school teachers and their students in their learning of science and mathematics with the help of college and university students, among others.

Target age group: Primary school and college students
Location: Montreal, disadvantaged area



Community oriented action: MATH outreach activities

Ildiko Pelczer, Concordia University

Objective: *Develop* a series of 15 hour-long outreach activities that cover a wide range of grade- levels and topics. These activities are meant to be implemented in schools through a close collaboration with the local community. Undergraduate and graduate students from the Mathematics and Statistics Department would be involved in the creation and carrying out of the activities, with the close direction of some of the department's professors.

Target age group: All
Location: Montréal

Une évasion mathématique

François Pomerleau, GRMS

Objective: *Invest* in the creation of escape-type game sets that can be "walked" in the different schools of Quebec. During the creation session of the GRMS 2020, several enigmas (problems) will be prepared in order to be able to propose turnkey game sets to teachers. This bank of riddles can be improved with the help of teachers who will use the sets with their students.

Target age group: Secondary
Location: All regions of Quebec

De l'école à la vie

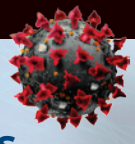
Catherine Verret,
Educational Consultant, Capitale School Board

Objective: *Provide* free access for teachers at the Cité regional school, by June 2021, to a dozen mathematics centers that will link the objectives of the CAPS program (aimed at making students functional in the workplace and in everyday life) and the PFEQ/Progression des apprentissages (addressing the mathematical aspect of these skills) with materials adapted to the requirements of modern life and the autistic clientele.

Target age group: Students with autism
Location: Quebec City

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.



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. The CRM also signed an agreement in 2014 with the Agencia Estatal Consejo Superior de Investigaciones Científicas (Spain) and agreements in 2016 with the Czech Technological University and the Instituto Nacional de Matematica Pura e Aplicada (Brazil). 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.

The CNRS Unité Mixte Internationale at the CRM

A few years ago the Centre National de la Recherche Scientifique (CNRS) in France decided to create at the CRM a UMI (i.e., a research unit outside of France), within the framework of a formal agreement between the CNRS and the Université de Montréal. The official name of this UMI is “Centre de recherches mathématiques – UMI 3457” and it was inaugurated in October 2011. The UMI at the CRM has been extremely successful since its creation, thanks to the outstanding work of its directors: Laurent Habsieger (2011-2015), Emmanuel Giroux (2015-2019) and Olivier Lafitte (2019-). The UMI provides financial support to French researchers so that they can visit the CRM for long or short periods of time. It 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

CIRANO
Allier savoir et décision

thematic programs and other activities. The agreement between the CNRS and the Université de Montréal was renewed for five years in 2015. When the President of France visited Québec in November 2014, the CNRS and the FRQNT signed an agreement providing for the financial support by FRQNT 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

Legally speaking the CRM is a Université de Montréal research center and has six university partners: Université de Montréal, McGill University, Université du Québec à Montréal, Concordia University, Université Laval, and Université de Sherbrooke. Université de Montréal provides the CRM with its office space and an operating grant and the support of the other partner universities consists mainly of a support to the CRM laboratories. 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, featuring 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 (ncm2), a consortium of research centers 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 centers 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). From 2014 to 2018, the creation and fostering of CRM/industry partnerships took place within the framework of the Institutes Innovation Platform (IIP), a project of the three Canadian mathematics institutes supported by NSERC.

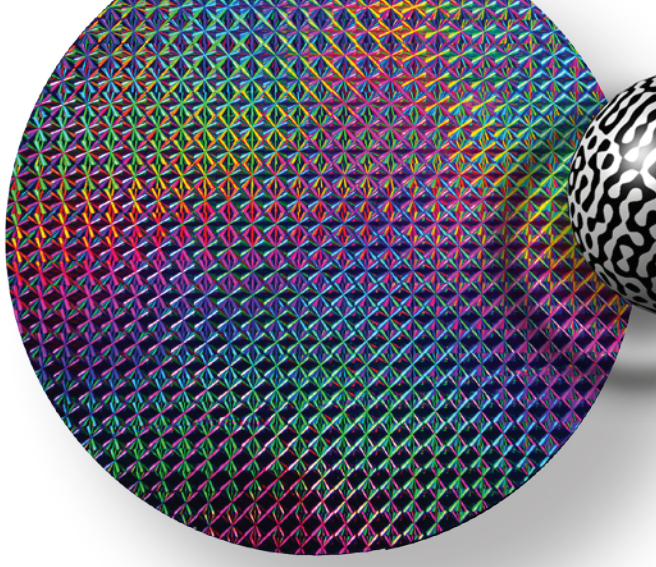
Collaborations with Professional Societies

The CRM and the other Canadian mathematics institutes extend some financial support for the organization of the meetings of Canadian societies in the mathematical sciences. In particular, in 2018–2020, the CRM with the Fields Institute and PIMS supported the Summer and Winter Meetings of the Canadian Mathematical Society, the Annual Meeting of the Statistical Society of Canada, and the Annual meeting of the Canadian Applied and Industrial Mathematics Society. The CRM also sponsored the Canadian Mathematical Society’s summer math camps.

Collaboration with Schools, Colleges, and Universities

Thanks to the commitment of the Quebec government and Quebec schools and universities

The national EnAvantMath! initiative provides the CRM with new opportunities for action and regulations by enabling it to gain exposure to new territories of intervention. Sponsored by the Ministry of Finance of Québec, and carried out in collaboration with the CIRANO, the EnAvantMath! initiative empowers the CRM to fulfill its mission as a knowledge mobiliser and as a leader in fostering and promoting mathematics in Québec, whether in the field of education, of training or in the Community, and hence, in citizenship action. The 13 projects in which we are engaged (2019-2020) as well as studies undertaken by the CRM-CIRANO consortium are already exploring new horizons for the benefit of the CRM.



Publications

Publications are an important part of the CRM's contribution to the dissemination of research in the mathematical sciences. The CRM has long published two series in collaboration with the American Mathematical Society (AMS): the CRM Monograph Series and the Centre de Recherches Mathématiques Proceedings (formerly CRM Proceedings and Lecture Notes). The latter series is included in the Contemporary Mathematics series since 2013. Springer publishes and distributes the CRM Series in Mathematical Physics as well as the series entitled CRM Short Courses. In addition, the CRM has occasional collaborations with different publishing houses.

The CRM publishes «The CRM Newsletter» which contains news from the CRM and articles about its activities and research of its members and award recipients.

Titles published between 2018 and 2020

Contemporary Mathematics — American Mathematical Society Center de Recherches Mathématiques Proceedings

Characters in low-dimensional topology in honor of Steve Boyer, UQAM, Montreal, June 2018. Editors: Stephan Tillmann, Olivier Collin, Stefan Friedl, Cameron Gordon, Liam Watson, CONM/760, 2020

International Conference on Algebra and Related Topics: Part 2: Linear and multilinear algebra, Function spaces and related topics, Rabat, Morocco, July 2018. Editors: J. Mashreghi, A. Bourhim, Z. El Abidine Abdelali, L. Oubbi, CONM/750, 2020

Complex analysis and spectral theory, in celebration of Thomas J. Ransford's 60th birthday, Université Laval, May 2018. Editors: J. Mashreghi, G. Dales, D. Khavinson, CONM/743, 2020

Analytic Methods in Arithmetic Geometry (Proceedings of the Arizona Winter School 2016), Editors: Alina Bucur and David Zureick-Brown, CONM/740, 2019

Probabilistic Methods in Geometry, Topology and Spectral Theory. Editor: Dmitry Jakobson, CONM/739, 2019

CRM Monograph Series — American Mathematical Society

Elliptic Boundary Value Problems with Fractional Regularity Data: The First Order Approach, Alex Amenta and Pascal Auscher, CRMM/37, 2018

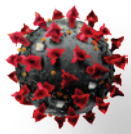
CRM Short Courses — Springer

Quantitative Tamarkin Category, Jun Zhang, 2020

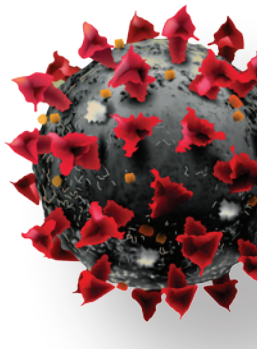
CRM Series in Mathematical Physics — Springer

Integrability, Supersymmetry and Coherent States, Editors: S. Kuru, J. Negro, L.M. Nieto, 2019

Symmetries and Integrability of Difference Equations – Lecture Notes of the Abecederian School of SIDE 12, Montreal 2016. Editors: Levi Decio, Winternitz Pavel, Verge-Rebelo Raphaël, 2018



CRM Committees



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, a Committee of Laboratory Directors, and an Industrial Committee. Here are the members of these committees in 2018–2020 (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 Management Committee nominated by the Board for a two-year mandate;
- Two regular members nominated by the Assembly for three-year mandates, normally renewable once;
- A laboratory director nominated by the Committee of Laboratory Directors for a two-year mandate, normally renewable once;
- The Chair of the International Scientific Advisory Committee;
- A postdoctoral member;
- The Vice-principals, Research, of the six partner universities of the CRM;
- Additional members nominated by the Board of Directors, with or without the right to vote, chosen within any relevant sector: business, industry, major Canadian or foreign research institutes, and public service.

In 2018–2020, the Board members were Luc Vinet (Director of the CRM), Véronique Hussin (Deputy Director of the CRM), Christiane Rousseau and Jacques Bélair (both of the Université de Montréal), Steven Boyer (Director of CIRGET), Gérard Ben Arous (Chair of the International Scientific Advisory Committee), Marie-Josée Hébert – Chair of the Board (Vice-Principal, Research, Université de Montréal), Christophe Guy (Vice-Principal, Research, Concordia), Martha Crago (Vice-Principal, Research, McGill), Catherine Mounier (Vice-Principal, Research, UQAM), Eugénie Brouillet (Vice-Principal, Research, Université Laval), Vincent Aimez (Vice-Principal, Research, Université de Sherbrooke), Hélène Desmarais (Centre d'entreprises et d'innovation de Montréal), and Luis Seco (University of Toronto and Sigma Analysis and Management).

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 2018–2020, this committee was chaired by Gérard Ben Arous (Courant Institute) and also included Afonso S. Bandeira (Courant Institute), Lia Bronsard (McMaster University), Ruth Charney (Brandeis University), Emmanuel Giroux (CNRS), Miranda Holmes Cerfon (New York University), Mark Lewis – CMS President (University of Alberta), Dusa McDuff (Columbia University), Sylvie Méléard (École Polytechnique, Saclay), Robert Pego (Carnegie Mellon University), Jeremy Quastel (University of Toronto), Dana Randall (Georgia Institute of Technology), Nicolai Reshetikhin (University of California, Berkeley), Emmanuel Ullmo (Institut des hautes études scientifiques), Michael Ward (University of British Columbia), and Luc Vinet (Director of the CRM).

Local Scientific Committee

In 2018–2020, the Local Scientific Committee included Rustum Choksi (McGill University), Matilde Lalìn (Université de Montréal), Thierry Duchesne (Université Laval), Alexandre Girouard (Université Laval), Niky Kamran (McGill University), Hugh Thomas (UQAM), and Luc Vinet (Director of the CRM).

Management Committee

The Management Committee of the CRM consisted of Luc Vinet (Université de Montréal), Director of the CRM; Louigi Addario-Berry (McGill University), Deputy Director, Scientific Programming until Summer 2019; Véronique Hussin (Université de Montréal), Deputy Director, Publications and Communications; Jean-Philippe Lessard (McGill University), Deputy Director, Scientific Programming starting Summer 2019; and Odile Marcotte (UQAM and GERAD), Deputy Director, Partnerships.

Industrial Committee

The Industrial Committee of the CRM consisted of 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 Canada).

CRM IN NUMBERS

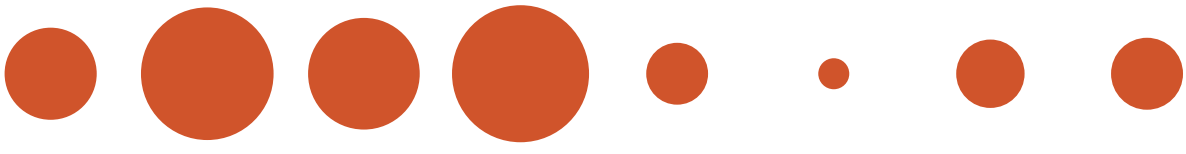
Sources of funding in 2018-2019
in thousands of $

FRQNT	$ 610
NSERC	$ 1264
Universities (funding)	$ 888
Universities (in-kind)	$ 1350
Simons Foundation	$ 275
Endowments	$ 69
Partner organizations	$ 213
Sales and registration fees	$ 168
	$ 4837

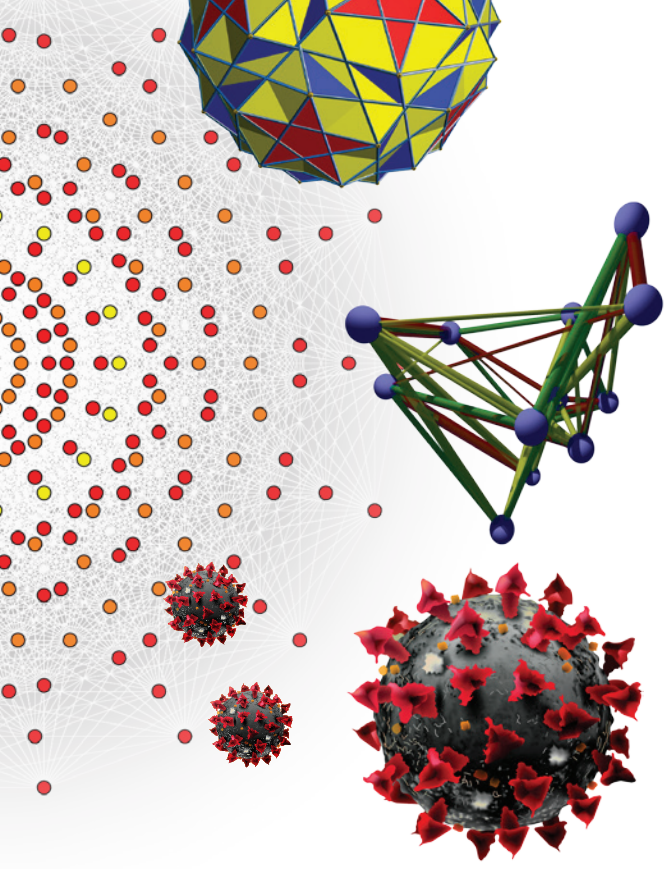
FRQNT | NSERC | Universities (funding) | Universities (in-kind) | Simons Foundation | Endowments | Partner organizations | Sales and registration fees

Sources of funding in 2019-2020
in thousands of $

FRQNT	$ 610
NSERC	$ 264
Universities (funding)	$ 896
Universities (in-kind)	$ 1350
Simons Foundation	$ 275
Endowments	$ 69
Partner organizations	$ 336
Sales and registration fees	$ 372
	$ 5172

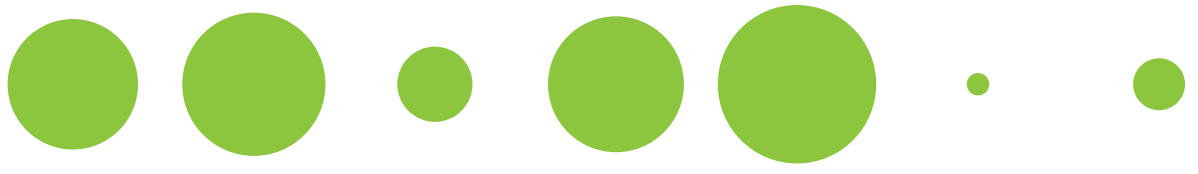


FRQNT | NSERC | Universities (funding) | Universities (in-kind) | Simons Foundation | Endowments | Partner organizations | Sales and registration fees



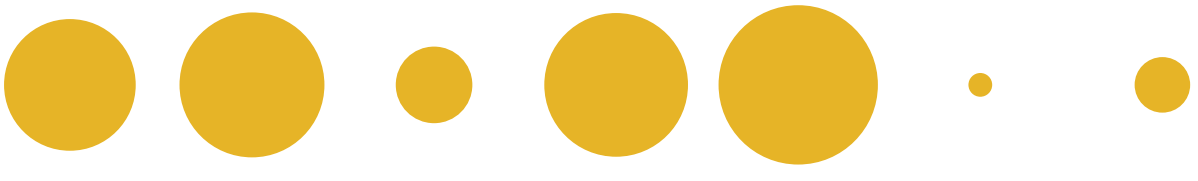
Use of funds 2018-2019 in thousands of $

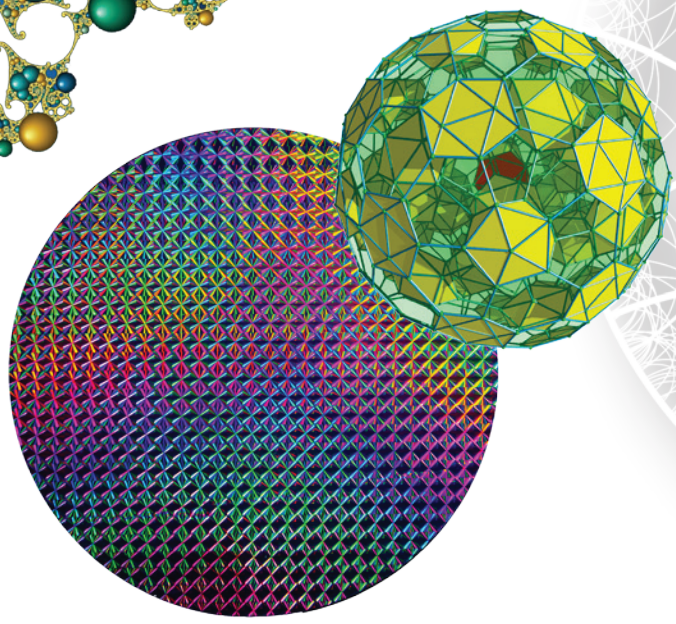
Laboratories	$ 915
Programs	$ 1103
Postdoctoral fellows	$ 304
Management and staff	$ 993
Spaces and services (in-kind)	$ 1350
Communications	$ 27
Operating	$ 145
	$ 4837



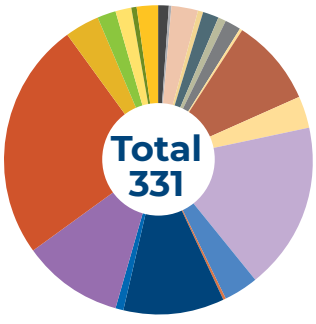
Use of funds 2019-2020 in thousands of $

Laboratories	$ 922
Programs	$ 1117
Postdoctoral fellows	$ 312
Management and staff	$ 1098
Spaces and services (in-kind)	$ 1350
Communications	$ 30
Operating	$ 164
	$ 4993



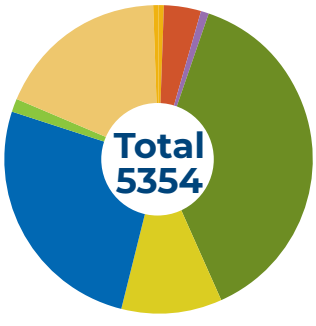


Affiliation of the regular and associate members (researchers) of the CRM and its laboratories

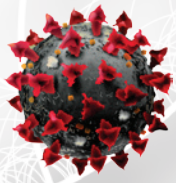


CNRS, France	3	Université de Sherbrooke	12
École de technologie supérieure	1	Université du Québec à Chicoutimi	1
École Polytechnique de Montréal	9	Université du Québec à Montréal	35
Google Brain Montréal	2	Université du Québec à Trois-Rivières	3
HEC Montréal	6	Université Laval	35
INRS	2	McGill University	82
Québec, Cegeps	6	Other, Canada	12
Microsoft Research	1	Other, France	7
Concordia University	30	Other, USA	5
University of Ottawa	11	Other, UK	2
Université de Montréal	58	Other, World	8

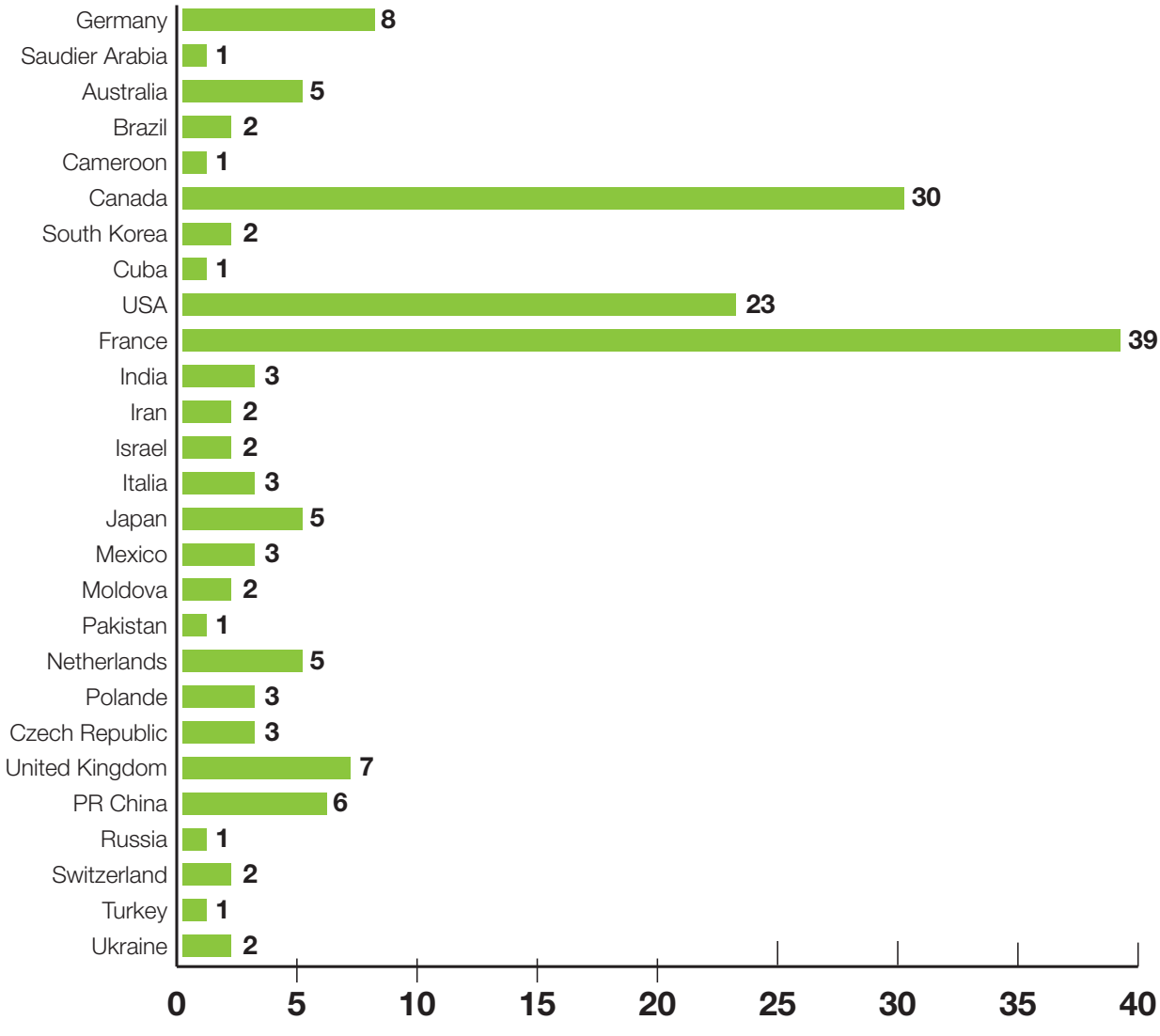
Regional origin of participants in CRM activities, 2018-2020



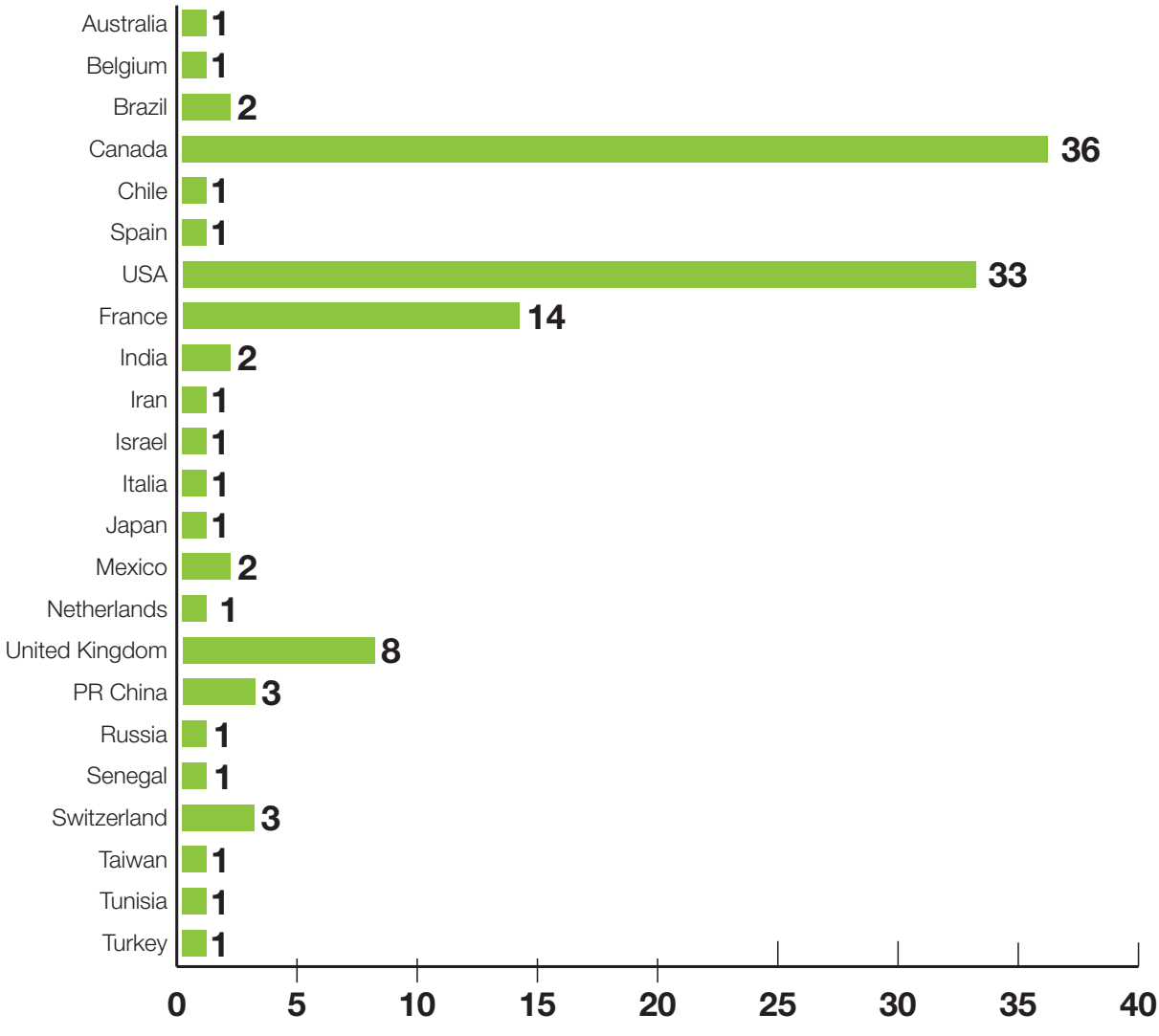
Africa	19
Asia	208
Australia & N.Z.	52
Québec	2038
Canada (other prov.)	557
USA	1408
America (other)	68
Europe	972
Middle East	32



Number of visiting researchers by country (one-month stay and longer) (163)



Number of postdoctoral researchers by country of PhD (117)



CRM Management & Staff

Executive

Luc Vinet	Université de Montréal Director
Louigi Addario-Berry	McGill University (mandate ended in June 2019) Deputy Director – Scientific Programs
Véronique Hussin	Université de Montréal Deputy Director – Publications & Communications
Jean-Philippe Lessard	McGill University (mandate began in July 2019) Deputy Director – Scientific Programs
Odile Marcotte	UQAM & GERAD (mandate ended in December 2019) Deputy Director – Partnerships

Administration & Research Support

Liliane Antoinette	Secretary (starting in April 2019)
Wendy Barrientos	Administrative Clerk (until June 2019)
Diane Brulé-De Filippis	Administrative Technician
Vincent Masciotra	Head of Administration
Hernando Naranjo	Financial Officer
Lucie Vincent	Secretary (until April 2019)*

Scientific Events

Sakina Benhima	Coordination Officer
Virginie Leduc	Coordinator (starting in August 2019)
Guillermo Martinez-Zalce	Coordination Officer
Louis Pelletier	Coordinator (until September 2019)*
Chantal Thibodeau	Administrative Technician

IT Systems

Ricardo Briceño	Systems Administrator (starting in December 2018)
Daniel Ouimet	Systems Administrator (until December 2018)*

Communications & Publications

Josée Leclerc	Senior Advisor (starting in July 2019)
André Montpetit	TeX Expert & Office Software Administrator (until June 2019)*
Suzette Paradis	Webmaster (until December 2019)*

* retirement

CENTRE
DE RECHERCHES
MATHÉMATIQUES

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