Four Aisenstadt Chair lecturers will visit the CRM during the 2008-2009 thematic year “Probabilistic Methods in Mathematical Physics.” We report here on the series of lectures of Wendelin Werner (Université Paris-Sud 11) and Andrei Okounkov (Princeton University), both of whom are Fields Medalists, who visited the CRM in August and September 2008 respectively. The other Aisenstadt Chairs will be held by Svante Janson (Uppsala University) and Craig Tracy (University of California at Davis).

Wendelin Werner

Wendelin Werner est un spécialiste de la théorie des probabilités. Il a obtenu son doctorat en 1993 sous la direction de Jean-François Le Gall. Il est professeur au laboratoire de mathématiques à l’Université Paris-Sud XI à Orsay depuis 1997, ainsi qu’à l’École normale supérieure depuis 2005. Avec ses collaborateurs Greg Lawler et Oded Schramm, il a montré que la probabilité de deux marches aléatoires planaires qui s’évitent décroît comme $n^{-5/8}$ où $n$ est la longueur des marches et a déterminé la dimension de Hausdorff ($= \frac{4}{3}$) de la frontière extérieure du mouvement brownien planaire. Ses travaux sur l’équation de Loewner stochastique et sur les ensembles de boucles conformes ont déjà eu un impact profond sur la description mathématique des phénomènes critiques en deux dimensions.


Les phénomènes critiques

L’étude des transitions de phase en physique a commencé il y a plus d’un siècle, mais ses progrès importants ont été accomplis depuis les années quarante du XXe siècle. Son objet touche des phénomènes physiques variés, dont certains tombent sous l’expérience de tous les jours, comme l’ébullition de l’eau ou la miscibilité de gaz et de liquide, par exemple dans les boissons gazeuses. Dans pratiquement tous ces phénomènes, une quantité macroscopique possède un comportement singulier (suite à la page 2)

Andrei Okounkov

A metaphor from an ancient fragment by Archilochus “The Fox knows many things but the Hedgehog knows one big thing” was used by Isaiah Berlin as title and theme of his essay on Tolstoy’s view of history (“...by nature a fox, but believed in being a hedgehog”) [1]. It is also very suitably applied to styles in science. In his presentation of the work of Andrei Okounkov when he was awarded the Fields medal at the 2006 International Congress of Mathematicians in Madrid, Giovanni Felder said: “Andrei Okounkov’s initial area of research was group representation theory, with particular emphasis on combinatorial and asymptotic aspects. He used this subject as a starting point to obtain spectacular results in many different areas of mathematics and mathematical physics, from complex and real algebraic geometry to statistical mechanics, dynamical systems, probability theory and topological string theory. The research of Okounkov has its roots in very basic notions such as partitions, which form a recurrent theme in his work...at its core (is) the idea that partitions and other notions of representation theory should be considered as random objects with respect to natural probability measures. This idea was further developed by Okounkov, who showed that, together with insights from geometry and ideas of high energy physics, it can be applied to the most diverse areas of mathematics.”

This would appear to describe the work of a fox but, as with Tolstoy, things are not necessarily as they seem. The fact that Okounkov’s work intersects so many fields of mathematics and mathematical physics may appear astonishing to
Wendelin Werner
(suite de la page 1)

en fonction des paramètres du système. Voici un exemple mathématique célèbre, celui de la percolation.

Fig. 1. Une interface $\gamma_{12}$ est tracée en (a), une trajectoire du processus SLE$_6$ en (b).

D’un réseau triangulaire planaire de maille unité, considérons une région de la forme d’un triangle équilatéral dont les côtés ont longueur $N$, avec $N$ pair. Le site médian de la base est l’origine. Les sites à la frontière de la région sont peints en blanc si leur coordonnée horizontale est positive, en noir autrement. Pour les autres sites (intérieurs), leur couleur sera noir avec probabilité $p \in [0, 1]$, blanc avec probabilité $1 - p$. Une interface $\gamma_N$, séparant les sites noirs des blancs, commence (presque) à l’origine, suit le réseau dual hexagonal et quitte la région triangulaire (presque) au sommet. Soit $d(p, N)$ la probabilité que cette interface, issue de l’origine, touche le côté droit avant le côté gauche. Il est possible de montrer que la limite de $d(p, N)$ lorsque $N \to \infty$ est $0$ lorsque $p < \frac{1}{2}$ et $1$ lorsque $p > \frac{1}{2}$. Donc l’« observable » $\lim_{N \to \infty} d(p, N)$ possède un comportement singulier en $p = \frac{1}{2}$. (Pour cette raison $p_c = \frac{1}{2}$ est nommé la probabilité critique pour cet exemple.) Cette observable prend la valeur $\frac{1}{2}$ en $p = p_c$. D’autres observables peuvent aussi être étudiées, par exemple le nombre moyen de sites dans la plage connecte de sites noirs contenant l’origine.

Deux conjectures

Cet exemple se prête à de nombreuses généralisations. Il est possible de changer le réseau triangulaire pour un autre réseau périodique ou d’étudier la percolation en d’autres dimensions, par exemple sur le réseau $\mathbb{Z}^d$ ou sur une région finie de ce réseau. D’autres modèles peuvent être aussi proposés pour lesquels la couleur d’un site (ou l’état de son spin) dépend de celles de ses voisins, comme pour les modèles d’Ising et de Potts. Pour tous ces modèles, l’existence d’un point critique et les propriétés en ce point lorsqu’il existe dépendent de la dimension du réseau. Mais les physiciens sont convaincus, par des arguments théoriques et des simulations numériques, que pour une dimension donnée les propriétés critiques sont indépendantes du réseau choisi. Cette indépendance constitue l’hypothèse d’universalité. Cette conjecture demeure un des problèmes majeurs du sujet.

Une autre hypothèse importante est celle de l’invariance conforme. Elle fut introduite dans le cadre des phénomènes critiques au début des années 80 par Belavin, Polyakov et Zamolodchikov. Une forme de cette hypothèse, suggérée par Aizenman, est particulièrement simple à formuler. Changeons l’échelle de sorte que le côté de la région triangulaire conserve une longueur unité lorsque $N$ varie et notons par $\Gamma_N$ l’interface ainsi obtenue. Fixons $p = p_c$ et considérons maintenant les interfaces commençant au sommet. Divisors la base de la région en deux segments, le gauche de longueur $x \in [0, 1]$, l’autre de longueur $1 - x$. Une seconde observable est la probabilité $\pi(x)$ que, dans la limite $N \to \infty$, l’interface $\Gamma_N$ issue du sommet touche le segment gauche avant le droit. Soit maintenant une transformation conforme $\phi$ sur un ouvert contenant la région triangulaire. L’image du triangle par cette transformation est maintenant tracée sur le réseau triangulaire qui, lui, demeure inchangé. L’hypothèse d’invariance conforme stipule que, dans la limite de la maille du réseau allant vers zéro, la probabilité qu’une interface issue de l’image du sommet atteigne l’image du segment gauche avant celle du droit demeure $\pi(x)$.

SLE


Fig. 2. Une courbe $c$ est progressivement retirée du demi-plan par la famille de transformations conformes $g_t$ de Loewner.

Le lien entre la loi limite de $\Gamma_N$ et le mouvement brownien est fait à l’aide d’un résultat classique de la géométrie conforme. Soit une courbe $c : [0, T] \to \mathbb{H} \cup \partial \mathbb{H}$ dans le demi-plan supérieur $\mathbb{H}$ et l’axe réel dont le point initial est en l’origine. (Voir Figure 2(a).) Supposons que cette courbe ne touche ni l’axe réel (sauf l’origine) ni elle-même. (Ces hypothèses sont trop restrictives, mais elles simplifient la présentation.) Alors le complément $C$ de cette courbe dans $\mathbb{H}$ est homéomorphe au demi-plan $\mathbb{H}$. Par le théorème de Riemann il existe donc une transformation conforme envoyant $C$ sur $\mathbb{H}$. Il est même possible de trouver

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Prizes

The 2008 CAP – CRM Prize in Theoretical and Mathematical Physics

The CAP – CRM Prize is given conjointly by the Canadian Association of Physicists (CAP) and the CRM every year since 1995. It was awarded this year to Richard Cleve from the University of Waterloo for fundamental results in quantum information theory, including the structure of quantum algorithms and the foundations of quantum communication complexity. Richard Cleve received the 2008 Prize during the CAP's awards banquet that was held at Laval University on June 10th, 2008.

Richard Cleve is an outstanding computer scientist who has worked at the boundary of physics, mathematics and computer science. His work has transcended the area of computer science to have a broad impact on the physics of quantum information.

Richard Cleve gives the Prize Lecture at Université Laval.

Richard Cleve has made seminal contributions to quantum information science. He has shown how generic quantum algorithms can be broken into the fundamental physical building blocks, the so called one and two qubits gates. Today most physical implementation of quantum computers use this result. He has also created the field of quantum communication complexity which assesses the resources required to perform tasks using quantum systems. He has demonstrated how a quantum version of quantum walks gives an exponential algorithmic speed up compared to its classical counterpart. He has also been involved in the first experiment on order-finding on a quantum computer prototype.

Besides being a first class researcher, Richard Cleve has been instrumental in building quantum information processing in Canada. He founded and was the impetus behind the quantum group at the University of Calgary before he moved to the Institute for Quantum Computing at the University of Waterloo, where he holds the Quantum Information Chair. He is also a research associate at the Perimeter Institute for Theoretical Physics, a founding fellow of the Quantum Information Processing program at the Canadian Institute for Advanced Research, and Team Leader at QuantumWorks, a NSERC innovation platform bringing together academia, government and industry to develop quantum information processing in Canada.

The 2008 CRM – SSC Prize in Statistics

The CRM – SSC Prize is given conjointly by the Statistical Society of Canada (SSC) and the CRM every year since 1999. It was awarded this year to Paul Gustafson, Professor in the Department of Statistics at the University of British Columbia (UBC), for his contributions to Bayesian statistical methodology and its application to epidemiology that have had an immense impact in statistics, biostatistics and public health. Paul Gustafson received the 2008 Prize at the joint meeting of the SSC and the Société française de Statistique held in Ottawa in May 2008.

Within 15 years of his Ph.D., Paul Gustafson has made outstanding contributions to the understanding of Bayesian statistical inference, to the implementation of the Bayesian paradigm in the health sciences, and to the development of computational algorithms for Bayesian inference. His work displays a deep knowledge of the foundation of statistical reasoning and a true ability to make substantial contributions to diverse domains of application. He has written key papers in several areas of statistics such as survival analysis, the analysis of count data, computational methods, and disease mapping. He has made solid methodological contributions through his collaborative work with epidemiologists, medical researchers, and psychologists.

Paul Gustafson has made seminal contributions to quantum information science. He has shown how generic quantum algorithms can be broken into the fundamental physical building blocks, the so called one and two qubits gates. Today most physical implementation of quantum computers use this result. He has also created the field of quantum communication complexity which assesses the resources required to perform tasks using quantum systems. He has demonstrated how a quantum version of quantum walks gives an exponential algorithmic speed up compared to its classical counterpart. He has also been involved in the first experiment on order-finding on a quantum computer prototype.

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Paul Gustafson received the CRM – SSC Prize in Statistics from Louis-Paul Rivest (Université Laval).

Paul Gustafson obtained his B.Sc. in Mathematics in 1990 and his M.Sc. in Statistics in 1991 from the University of British Columbia. He completed his Ph.D. in 1994 at Carnegie-Mellon University. He shares Canadian bonds with his supervisor Larry Wasserman, the 2002 recipient of the CRM – SSC award. Paul is a third generation CRM – SSC winner since Larry Wasserman’s adviser, Rob Tibshirani, was the 1999 recipient of this award. He held a Postdoctoral fellowship at the University of British Columbia in 1994, where he was appointed Assistant Professor in 1995, Associate Professor in 2000 and Full Professor in 2005. He obtained a UBC Killam Faculty Research Fellowship in 2001.
Andrei Okounkov
(continued from page 1)

those who encounter his results separately in the context either of group representation theory or combinatorics, probability, algebraic geometry, algebraic topology, integrable systems, statistical physics, growth phenomena, topological gravity, etc. However, for those working in related fields, most especially, Integrable Systems, which is well represented at the CRM, these topics and Okounkov’s contributions to them do not seem quite as diverse as they might otherwise appear.

To begin with, when looked at closely, there really are a number of common elements that point to an underlying unity of ideas and economy of methods. The representation theory of Lie groups is well known to be closely related to that of finite and discrete groups, in particular, through the essential role played by the Weyl group acting on the root lattice. The irreducible group characters for the unitary and general linear groups, known as Schur functions, were originally introduced and studied by Jacobi in the context of symmetric polynomials and their combinatorial properties long before the notion of a Lie group or its representations was known. There is a well-known “duality” between the unitary (or general linear) group in N dimensions, and the symmetric group S_N of permutation of N elements. In particular, the irreducible characters are determined by the same essentially combinatorial objects, partitions, in both cases. Partitions, moreover, have their own planar geometrical significance when represented by Young diagrams, which are formed by stacking aligned rows of adjacent square boxes. This construction extends in fact very naturally to three dimensions, with the squares replaced by cubes. When a three dimensional partition is represented through projection to a plane from a suitable perspective, we obtain what appears as a rhombus tiling of a hexagon, which can be split into one by equilateral triangles. This leads to natural variations, where the boundary is replaced by more general polygons. Considering the tiling as a graph, we also have a dual tiling by hexagons or, after splitting the rhombi into pairs of equilateral triangles, we may “forget” the three dimensional origins, and order the pairs in some way, identifying an adjacency matrix (the Kasteleyn matrix) which recovers the three dimensional data. This also provides the key tool in computing the detailed combinatorial/probabilistic quantities characterizing configurations sharing certain given boundary requirements through determinantal formulae.

Connecting the centers of the triangles pairwise gives a “dimer covering” (or “perfect matching” of the associated set of vertices). Moreover, the three-dimensional interpretation can be used to associate a non-intersecting set of “horizontal paths” and, if the original 3-D partition was random, these, too may be viewed as a set of random paths in the plane, having a certain probabilistic weight, thus defining a random process. It is also natural to consider the limit where the number of tiles, or cubes is infinite, and all jaggedness is eliminated by taking a sufficiently distant perspective. We then arrive at “universal shapes” bounding the regions of “disorder.” These turn out, very generally, to be real algebraic curves, leading us into the realm of algebraic geometry. The “large number of tilings” corresponds to large partitions, which in the 2-D case is related also to the asymptotics of group representations and characters. Viewed as random processes consisting of non-intersecting paths, the large number limit may be interpreted as determining a diffusion process, which is also analogous to the processes that govern the eigenvalues of chains of random matrices in the continuous time limit.

The connections between random partitions, random tilings and random processes was the theme of one of the largest workshops of the CRM 2008–2009 Thematic Program on Probabilistic Methods in Mathematical Physics, which took place Sept. 1–6, 2008 (URL: crm.umontreal.ca/Tilings08/index_e.shtml) and overlapped, both in timing and content with the series of Aisenstadt Chair Lectures “The Algebra and Geometry of Random Surfaces” given by Andrei Okounkov. The first two of his lectures were included as part of the program of the workshop, while the remaining four lectures systematically developed new approaches to problems of random tilings and asymptotic bounding curves that Okounkov has pioneered, featuring especially the link with noncommutative rings and algebraic geometry.

To obtain concrete results in this direction requires enumerative computations of probabilities, statistical correlations between the various random objects involved, and characterization of their asymptotic properties. Making sense of the relations between the various linked interpretations and applications requires a deep understanding of the underlying structure. Okounkov’s contributions to this very rapidly evolving field has been characterized by his introduction of distinctive approaches that help both to compute concretely and make sense of the underlying rather subtle structure by bringing new concepts and insight onto the scene. Okounkov excels at neatly characterizing the combinatorial objects and rules that are involved with the help of new approaches, such as noncommutative geometry and operator methods, that seem quite unusual and surprising in this context in comparison with more standard combinatorial and probabilistic methods. The constructions are ingeniously devised to reduce the complexity of the computations at hand, while giving fresh new insights into the the objects under study.

One such approach consists in expressing a certain probabilistic weight, or the partition function on a statistical ensemble, or a combinatorial generating function, as matrix elements of some infinite dimensional operator on a Fermionic Fock space,
The year 2010 marks the 50th anniversary of the publication of Eugene Wigner’s famous essay on the “unreasonable effectiveness of mathematics in the natural sciences.” The intervening five decades have witnessed an explosion in the variety and scope of the applications of mathematics, to the extent that one can now speak of an ongoing “mathematization” of many branches of science and indeed of society as a whole. Number theory, traditionally viewed as far removed from the sphere of applications, now plays a central role in questions pertaining to the design of efficient networks as well as in areas like robotics, computer vision, statistics, coding theory, computer security, and cryptography.

The 2010 Winter theme semester Number theory as experimental and applied science, organized by Henri Darmon and Eyal Goren (McGill) will be devoted to recent developments in number theory with a specific focus on significant practical applications, as well as on the many ways in which the field stands to be affected by the emergence of new software and technologies.

The first activity of the theme semester will take place several months ahead of the semester, during the summer of 2009: the SMS Summer school on Computational and Experimental Approaches to Automorphic Forms, organized by Michael Rubinstein (Waterloo) and Andreas Strömbergsson (Uppsala) will be held for two weeks from Monday June 22 to Friday July 3, 2009.

The explosive development of the theory of automorphic forms on GL(2) in the second half of the twentieth century allowed a number of spectacular recent advances in number theory. The most visible of these was the proof of the Shimura – Taniyama – Weil conjecture and of Fermat’s Last Theorem almost 15 years ago, but one should also mention other highlights like the subsequent proof of the Serre conjectures relating two-dimensional mod p Galois representations to modular forms, and the important progress on the Fontaine – Mazur conjectures concerning p-adic Galois representations. Spurred in part by some of these breakthroughs, the last decade has witnessed significant arithmetic applications of the theory of automorphic forms on higher rank groups, such as the spectacular recent proof of the Sato-Tate conjecture and the ongoing work on the Iwasawa main conjecture exploiting Eisenstein series on unitary groups.

Automorphic forms on GL(2) are very accessible to machine calculation, and there has been a tremendous amount of activity devoted to developing efficient algorithms for computing with modular forms, and making tables of data related to modular forms widely accessible. For example, we now have extensive on-line tables of all elliptic curves over \( \mathbb{Q} \) of conductor up to 130,000, a database which contains several million elliptic curves and whose calculation, based on the truth of the Shimura – Taniyama conjecture and on the modular symbol method for computing holomorphic cusp forms, is both a computational tour de force and a real treasure trove for researchers interested in the arithmetic of elliptic curves.

By contrast, the realm of automorphic forms on groups of higher rank has been much less explored computationally, and this presents a great number of interesting challenges. It would be of great interest, both for theoretical as well as experimental purposes, to bring the theory of automorphic forms as much as possible within reach of practical machine calculations.

The purpose of the SMS is to bring together a number of experts who have been leaders in both the theoretical and more computational aspects of the theory of automorphic forms and L-functions, who will offer introductory-level courses aimed at presenting graduate students and postdoctoral fellows with the state of the art in the subject and report on new advances which have not yet been covered in a forum of this sort.

The lectures of the school will include:

- Henri Darmon (McGill) and Eyal Goren (McGill), Background and prerequisites.
- Andrew Booker (Bristol), Maass forms and L-functions.
- Noam Elkies (Harvard), K3 surfaces of high Picard number and their moduli.
- Dorian Goldfeld (Columbia), Automorphic forms and L-functions in higher rank.
- Erez Lapid, (Hebrew University), The Arthur – Selberg trace formula and applications.
- Kamal Khuri-Makdisi (American University of Beirut), Modular interpretation and equations for modular varieties.
- Michael Rubinstein (Waterloo), Algorithms for the computation of L-functions.
- Harold Stark (UCSD), Artin L-functions and special values at \( s = 0 \).
- Fredrik Strömberg (TU Clausthal), Maass waveforms for SL(2, \( \mathbb{Z} \)) and subgroups, from a computational point of view.
- Andreas Strömbergsson (Uppsala), Computations using the Selberg Trace Formula.
- Audrey Terras (UCSD), L-functions of graphs.
- Akshay Venkatesh (Stanford, Aisenstadt Chair), Eisenstein series.
- John Voight (Vermont), The algorithmic theory of quaternion algebras.

For more information about the SMS 2009, in particular for graduate students and postdoctoral fellows who would like to attend and apply for funding, please contact Sakina Benhima at benhima@CRM.UMontreal.CA.
une famille de transformations conformes $g_t$ qui retire la courbe $c$ jusqu’au point $t < T$. (Voir Figure 2(b).) L’équation de Loewner est une équation différentielle donnant cette famille de courbes $g_t$ uniqument. Le mouvement du point $g_t(c)$ sur l’axe réel dépend de la courbe $c$. Schramm a montré que, pour la loi limite de $\Gamma_N$, la loi de ce mouvement est $\sqrt{\beta_1 B_0}$ où $k = 6$ et $B_0$ est le mouvement brownien. La même construction, pour d’autres valeurs de $k$, a pu être liée à d’autres modèles critiques et le processus est donc nommé SLE$_k$.

**L’approche de la criticalité**

Les premiers travaux qui ont suivi l’introduction des techniques liées à SLE ont été limités aux limites d’échelle à la probabilité (ou température) critique. C’est en ces valeurs critiques que les lois limites sont décrites par SLE$_k$. Ces travaux laissaient donc intouché un chapitre important de la théorie des transitions de phase, celui du voisinage du point critique et des outils développés par les physiciens pour l’étudier les lois d’échelle et le groupe de renormalisation. Dans les années 60 et 70, des physiciens, dont Fisher, Widom, Kadanoff et Wilson, avaient proposé que le comportement de certaines observables auraient, proche du point critique, un comportement en loi de puissance et que leurs exposants seraient reliés à ceux apparaissant au point critique. Ce lien entre le modèle critique et le modèle près du point critique avait été exploré par Harry Kesten dans les années 80. Mais depuis quelques mois les probabilités ont franchi des étapes importantes pour révéler la finesse des phénomènes proches du point critique. Le dernier exposé de Werner était consacré à décrire ses résultats récents, obtenus avec Pierre Nolin, en percolation bidimensionnelle quasi critique.

Revenons aux interfaces $\Gamma_N$ partant du point médian de la base de la région triangulaire. Leur loi converge vers le processus SLE$_6$. Nous avons énoncé que la probabilité $d(p,N)$ de toucher le côté droit de la région avant le gauche avait un comportement limite singulier : $\lim d(p,N) = 0$ si $p < \frac{1}{2}$ et $1$ si $p > \frac{1}{2}$. Un processus limite plus fin est donc nécessaire pour étudier la région proche du point critique. À cette fin, Nolin et Werner définissent $p^*(N, \epsilon) = \inf \{ p : d(p,N) > \frac{1}{2} + \epsilon \}$ pour $\epsilon \in (0,\frac{1}{2})$. Ils peuvent alors montrer que, si une suite $\{p(N)\}_{N \in \mathbb{N}}$ est choisie de façon à ce que $p(N)$ soit proche de $p^*(N, \epsilon)$, alors une loi limite pour les interfaces $\Gamma_N$ peut être obtenue. Cette nouvelle limite est singulière par rapport à SLE$_6$, même si elle en partage les exposants critiques ; en particulier la dimension de Hausdorff des interfaces est presque sûrement $\frac{3}{4}$, comme pour les courbes de SLE$_6$. Voici donc un autre chapitre de l’étude des phénomènes critiques où les outils proposés par SLE se révèlent fondamentaux.

La communauté du CRM remercie Wendelin de lui avoir présenté de façon pédagogique les idées centrales de l’équation de Loewner stochastique en en révélant certains des développements récents.

**Andrei Okounkov**

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evaluated between given pairs of states. This brings the underlying calculations into direct contact with methods and ideas that are current in the theory of Integrable Systems and Quantum Field Theory. Another is based on noting that the adjacency matrices for on associated set of graphs corresponding to a dimer covering can be realized by multiplication in a noncommutative version of a polynomial ring. Such constructions, though not at all standard in probability theory or combinatorics, make use of tools that are quite familiar to mathematical physicists, who use them in a variety of settings, from quantum field theory to integrable systems to string theory.

Like Witten, who made remarkable use of ideas and methods from quantum field theory and other physics inspired tools to arrive at deep new results of a topological and algebraic geometric nature, Andrei Okounkov draws very profitably from the toolbox of mathematical physics to arrive at fresh new perspectives and results relating to problems in combinatorics, probability theory, group representation theory, topological invariants and algebraic geometry. Besides the fact that this involves some basic constructions in the theory of integrable systems and noncommutative geometry, there are also close connections appearing with results and methods in the spectral theory of Random Matrices, (which formed the subject of the preceding research workshop the 2008–2009 Thematic Program (Aug. 25 – 30, 2008. URL: crm.umontreal.ca/Matrices08/index_e.shtml). Building on such interconnections provides some of the “secret weapons” that have been so innovatively applied by Okounkov, enabling him to overcome hurdles that might otherwise have stumped specialists familiar only with the conventional methods of their individual domains.

The successful application of such methods to a wide range of problems of considerable current interest in a variety of domains not only points to deep underlying connections between them, but suggests that there must be much more along the lines pioneered by Andrei Okounkov that remains worthy of further investigation. His presence at the CRM during this very exciting thematic concentration period and his Aisenstadt lectures provided a great stimulus to those present, and an inspiration to some to carry on the investigation of the challenging range of ideas involved, deepening our understanding of the links between these diverse fields and the beautiful intrinsic structure that underlies them.

The workshop entitled “Mathematical Aspects of Quantum Chaos” was held at the CRM on June 2–7, 2008. Organized by N. Anantharaman (École Polytechnique, France), S. Nonnenmacher (CEA, France), Z. Rudnick (Tel Aviv University, Israel) and S. Zelditch (Johns Hopkins, USA), it was the first event of the thematic year on “Probabilistic Methods in Mathematical Physics.” It was attended by about 40 participants, a mixture of pure and applied mathematicians and theoretical physicists.

It is clear from the title that “quantum chaos” is a multidisciplinary topic. The term was coined by theoretical physicists and chemists in the 1970s, who were interested in the description of highly excited nuclear, atomic or molecular energy levels; in mathematical terms, the aim is the spectral analysis of certain Schrödinger operators. For the systems under scrutiny, no analytical formulas exist for eigenvalues or eigenfunctions, so one has to resort to semiclassical (high-frequency), numerical and/or statistical methods. The common denominator of these quantum systems is the fact that their limiting classical dynamics is (at least partly) chaotic. Soon, theoreticians preferred to study simpler systems, like 2-dimensional Euclidean billiards, or Riemannian manifolds of negative curvature, the chaotic properties of which had been investigated by the dynamical systems community. Some (less realistic, but even simpler) quantum models were then considered: quantum maps and quantum graphs. These systems allow “cheaper” numerical studies, but they also often allow a deeper analytical study. Some of these systems have strong arithmetical properties: their study forms a proper subfield called “arithmetic quantum chaos.”

These various “quantum chaotic systems” were mentioned during the workshop, which allowed the audience to appreciate their similarities and differences. A “metaconjecture” in the domain consists in identifying, from a statistical point of view, the eigenvalues and eigenfunctions of individual quantum systems, with those of a class of “random” systems, typically large random matrices. The Random Matrix Theory (RMT) conjecture which studies the short-distance correlations between eigenvalues (formulated by Bohigas–Giannoni–Schmidt in 1984) has recently received a renewed impetus in the theoretical physics community, due to a refined combinatorial analysis of long periodic orbits. These results, presented in the talks of S. Müller (Bristol) and P. Braun (Essen), are still far from making a full mathematical proof; the simple quantum graphs studied by G. Tanner (Nottingham) in this view already show the difficulty of the question.

On the other hand, the mathematical analysis of eigenfunctions has made significant progresses in the recent years. A now standard result in the domain is the Quantum Ergodicity (QE) theorem, which applies to most of the systems mentioned above. This theorem (first showed by Schnirelman, Zelditch and Colin de Verdière in the 70s and 80s) states that almost all the high-frequency eigenfunctions are “macroscopically equidistributed” across the full energy hypersurface, provided the corresponding classical dynamics is ergodic. J. Keating (Bristol) and A. Strohmaier (Loughborough) explained the subtleties of extending QE to quantum graphs, respectively to multi-component wavefunctions. Systems with a mixed dynamics (featuring regions of regular motion surrounded by a “chaotic sea”) were described in the talks of A. Bäcker (Dresden) and A. Barnett (Dartmouth); so far these systems resist a rigorous analysis.

As soon as QE was established, people conjectured that actually all high-frequency eigenfunctions are equidistributed, a statement referred to as Quantum Unique Ergodicity (QUE). This conjecture is still pending, except for the case of arithmetic systems. Lindenstrauss’s recent proof of QUE for Hecke eigenstates on arithmetic hyperbolic surfaces has been reviewed by L. Silberman (UBC), who also discussed possible extensions to some higher-rank symmetric spaces. An Arithmetic QUE result had been obtained before for quantum automorphisms of the 2-dimensional torus (or “quantum cat maps”) by Rudnick–Kurlberg; further advances in the statistics of quantum matrix elements were presented by P. Kurlberg (Stockholm). On the other hand, quantum cat maps also lead to explicit counterexamples to QUE, namely (nonarithmetic) eigenstates which are not equidistributed, but have a large probability weight (a “strong scar”) around a single periodic orbit. For automorphisms of higher-dimensional tori, D. Kelmer (Princeton) identified a family of eigenstates which are both “arithmetic” and localized on a strict submanifold of the phase space, thus disproving Arithmetic QUE for this system. Away from arithmetic systems, the use of the Kolmogorov–Sinai entropy was put forward by N. Anantharaman a few years ago, when she showed that high-frequency eigenfunctions on manifolds of (varying) analyticity (continued on page 19)
Multidisciplinary and Industrial Program
Programme multidisciplinaire et industriel

May 20 – 30, 2008. Summer School “Systems Biology Dynamics: from Genes to Organisms”
by Peter Swain (McGill)

The summer school was organised by the Centre for Non-linear Dynamics in Physiology and Medicine, and brought together 55 students, postdoctoral fellows, physicians, professors, and industry representatives from 16 countries for a two-week intensive course. The director of the school was Dr. Peter Swain of McGill University. The instructors were primarily members of the Centre and students associated with the Centre acted as teaching assistants. The mornings consisted of two 1.5 hour lectures and the afternoons of computer laboratory exercises using specifically designed and developed material.

The first week focused on non-linear modeling of physiological dynamics. Following an introductory day, subsequent topics included dynamics of normal and pathological behaviors in both neural and cardiac systems. The second week focused on modeling single cells and particularly their physiology and the genetic networks that create it. Applications included modeling cell replication and stochastic gene expression, inferring model structure from time series data, and synthetic biology, which was taught by Dr. Mads Kaern, a guest lecturer from the University of Ottawa.

The school was organised and supported partially by the CRM, MITACS and INRIA.

Deuxième atelier de résolution de problèmes industriels de Montréal, du 18 au 22 août 2008
de Odile Marcotte (UQÀM et GERAD)

Dans le cadre de son programme multidisciplinaire et industriel, le CRM organise des ateliers où des chercheurs, des représentants de l’industrie, des étudiants et des stagiaires postdoctoraux tentent de modéliser et de résoudre des problèmes proposés par des partenaires industriels. L’atelier qui s’est tenu du 18 au 22 août 2008 était le deuxième atelier de ce genre organisé par le CRM, et 14 chercheurs, 10 représentants de l’industrie et 22 étudiants ou stagiaires postdoctoraux y ont participé.

L’atelier fut organisé conjointement par le CRM, le GERAD, le rcm2 (Réseau de calcul et de modélisation mathématique), le CIRANO, MITACS et le CIRRELT, et financé par MITACS et le rcm2. Le comité organisateur était formé de Jean-Marc Rousseau (CIRANO et rcm2, président du comité), Eric Bosco (MITACS), Michel Gendreau (CIRRELT et Université de Montréal), Bernard Gendron (Université de Montréal), Alexandra Hae-
Gerhard Huisken

Gerhard Huisken pioneered the study of the mean curvature flow in the 80s and continued to be at the forefront of research in the area of curvature flows. In the 90s, in his work with Ilmanen, Huisken developed the theory of weak solutions to the inverse mean curvature flow and applied it to prove the Riemannian Penrose Inequality: the total mass of an asymptotically flat three-manifold of nonnegative scalar curvature is bounded below in terms of the area of each smooth, compact, connected “outermost” minimal surface (i.e., not separated from infinity by any other compact minimal surface) in the three-manifold. A 1998 ICMS speaker, Gerhard Huisken is also the recipient of the Medal of Australian Mathematical Society (1991) and the Leibniz Prize (2003). Since 2002, Huisken is Director and Scientific Member at the Max Planck Institute for Gravitational Physics.

Jean-Christophe Yoccoz

The winter semester 2008 “Dynamical Systems and Evolution Equations” at the CRM was focused on dynamical systems, and accordingly the Aisenstadt Lectures of May 9–12 were delivered by Jean-Christophe Yoccoz, one of the leading mathematicians working in this area. He delivered four in-depth lectures in the form of a series dedicated to the theory of interval exchange maps, the first lecture being of colloquium style. He also gave a lecture on affine interval exchange maps during the following week, which coincided with one of the major workshops of the thematic semester on dynamical systems and evolution equations. The lectures were given at a high level, but nonetheless were accessible, and many members of the CRM, as well as the visitors for the thematic semester, were able to benefit from them.

The central theme of this lecture series was the analysis of interval exchange maps. The class of diffeomorphisms of the circle has been a classical topic of study in dynamical systems since the days of Poincaré, Denjoy, and their contemporaries. At this point, the ideas of V. Arnold, J. Moser, M. Herman and J.-Ch. Yoccoz have given quite a refined picture of their conjugacy classes and their dependence upon rotation number and smoothness. The category of (generalized) interval exchange maps can be seen as the extension of this study to cases of piecewise-increasing discontinuous maps of the interval with more than one discontinuity. More specifically, a (standard) interval exchange map (IEM) is a one:one map of the interval \([0,1]\) which is locally a translation except at finitely many discontinuities. For example, if the number \(d\) of discontinuities is \(d = 1\), then an IEM is a rigid rotation. New and fascinating dynamical questions arise for \(d \geq 2\). Up to a point, the dynamics of IEMs is similar to the dynamics of rotations on the circle: there is a notion of generalized rotation number, and, when it is irrational, all orbits of the transformation are dense.

A major part of the lecture series was devoted to the detailed development of the theory of this generalized rotation number in the setting of interval exchange maps.

(continued on page 12)
The winter semester 2008 “Dynamical Systems and Evolution Equations” at CRM has focused on dynamical systems, interpreted in a broad sense so as to include applications to fundamental problems in differential geometry as well as in mathematical physics. The four principal topics of the semester involve, as a common theme, the interplay between classical dynamical systems and the qualitative properties of solutions of partial differential equations. They had been chosen because of the recent dramatic achievements, representing progress on a number of the most basic and difficult questions in this field. Among these, we find the proofs of the Poincaré conjecture and of Thurston’s geometrization conjecture for three manifolds. Also in Hamiltonian PDE, the analytic methods of Hamiltonian mechanics are making an impact on the study of the evolution of many of the principal nonlinear evolution equations of mathematical physics. These advances have had a broad impact in geometry and topology, and they shed light on the basic physical processes that are modeled by ODE and PDE.

Acknowledgements. The semester was supported by the NSF and the Clay foundation, in addition to CRM. We are very grateful to Eugene Wayne who piloted the NSF application.

There were six workshops during the semester and several advanced-level courses, including two Aisenstadt series of lectures. The semester started in January with two smaller events.

“Young Mathematicians’ Conference,” January 18 – 19, 2008
Organizers: Walter Craig (McMaster), Adrian Nachman (Toronto), Nilima Nigam (McGill), Dmitry Pelinovsky (McMaster), Mary Pugh (Toronto), Catherine Sulem (Toronto)

This workshop was the fifth annual Young Mathematicians’ Conferences and the first in Montréal. This is a conference of junior researchers in the areas of partial differential equations (PDEs) and Dynamical Systems, whose goal is to encourage scientific exchange, to create an opportunity for mathematicians in an early stage of their career to speak at a major organized conference, and to get to know each other and each other’s work. And this most recent one in Montréal definitely lived up to the high standards set by the previous meetings.

The two-day conference this January featured two plenary talks given by Ivar Ekeland (UBC) and Walter Craig (McMaster), and eleven twenty five minute talks given by junior mathematicians (advanced graduate students and postdocs). I. Ekeland spoke on the foundations of micro-economic theory and the role that the calculus of differential forms plays in the theory. W. Craig spoke on his recent work with A. Biryuk (a former junior YMC speaker) on new estimates for weak solutions of the Navier-Stokes equations, and their on the Kolmogorov–Richardson picture of the energy cascade and the power law behavior of the energy spectral function in fully developed turbulence. The talks given by the young mathematicians ranged from numerical modeling of fingering in porous media flows (M. Chapwanya, SFU), to complex dynamical systems (R. Roeder, Toronto), to a survey of recent results related to the Minkowski problem for convex domains and their generalizations (J.-F. Li, McGill).

Organizers: Walter Craig (McMaster), Pengfei Guan (McGill) and Christiane Rousseau (Montréal)

This workshop took place right at the beginning of the semester and allowed the organizers and the participants, in particular the associated postdoctoral fellows, to know each other and to have an introduction to each other’s research. The workshop started by the invited lecture of P. Mardešić (Dijon). The other lectures have been given by the organizers of the core workshops and the CRM postdocs associated to the semester.

These two workshops were followed by a two months break. Then started a blitz of four sparkling workshops.

Workshop “Spectrum and Dynamics,” April 7 – 11, 2008
Organizers: Dmitry Jakobson (McGill) and Iosif Polterovich (Montréal)

The central theme was the interplay between the theory of dynamical systems and spectral geometry, and the conference brought together the leading experts in these two fields. In particular, the workshop focused on applications of dynamics to the study of spectral asymptotics. Main topics included: spectral asymptotics on negatively curved manifolds and hyperbolic dynamics, Laplace and length spectra, elliptic operators on vector bundles and partially hyperbolic flows, billiards and spectral theory on manifolds with boundary, ergodic theory of group actions, and theory of thermodynamic formalism. A poster session was organized.

Mini-courses: The program of the workshop included two mini-courses, which continued during the week after the workshop.
S. Nonnenmacher (CEA-Saclay) presented a mini-course on recent spectacular results on the entropy of chaotic eigenstates, obtained by N. Anantharaman, himself and H. Koch. They show that the entropy of semiclassical measures (limit measures associated to a sequence of chaotic eigenstates) is bounded from below by approximately half the maximal en-
tropy. This implies that high-energy chaotic eigenstates are “at least half-delocalized.” This partially answers a long-standing question in the theory of quantum chaos.

R. Schubert (Bristol) presented an introduction to his work on long-time behavior of wave propagation on negatively curved manifolds. Until recently, wave propagation in chaotic systems has been well understood up to logarithmic times only: this is the so-called Ehrenfest time barrier in quantum mechanics. Schubert’s results can be viewed as the first step towards understanding the wave propagation up to polynomial times, which is an outstanding problem in mathematical physics.

The proceedings of the conference will be published in the CRM Proceedings and Lecture Notes, edited by D. Jakobson, S. Nonnenmacher and I. Polterovich.

Organizers: Vestislav Apostolov (UQAM), Pengfei Guan (McGill) and Alina Stancu (Concordia)

This 10-days workshop, held during the spring of 2008, was focused on the study of various evolution equations in geometry and general relativity, including intrinsic curvature flows with a focus on Ricci and Kähler – Ricci flows, and extrinsic curvature flows — mean and inverse mean curvature flows, homogeneous and non-homogenous Gauss curvature flows, relativity.

The workshop was attended by over 40 participants, ranging from physicists to geometers to analysts. Most participants were speakers. Many new results were reported for the first time during the workshop and many participants left Montreal ready to work on new projects. We highlight below the four lectures series in which the lecturers did a wonderful work in surveying vibrant fields of current research.

Gerhard Huisken gave a cycle of 4 lectures, including the Aisenstadt distinguished lecture, thus providing a comprehensive survey on geometric variational problems in General Relativity, including aspects of the mean and inverse mean curvature flows, different concepts of mass and their relationship with isoperimetric inequalities.

Burkhard Wilking lectured on Ricci flow and its spectacular applications to the recent resolution of classical curvature pinching conjectures in Riemannian geometry, including the 1/4 pinching sphere theorem.

Lei Ni gave a far-reaching introduction to Ricci flow with a special attention to solitons. After explaining the Li – Yau – Hamilton Harnack inequalities for Kähler – Ricci flows, he presented a detailed study of gradient Ricci solitons and their canonical forms. Xiuxiong Chen surveyed the exciting recent breakthrough in the theory of extremal Kähler metrics that he and Tian made by proving their uniqueness within a fixed Kähler class, as well as the boundedness of the (relative) K-energy, by using suitable approximations of the geodesics in the space of Kähler metrics. He linked these results to the convergence of the Kähler – Ricci and Calabi flows.

Thus, in 10 intensive days, the program succeeded in tying together most of the new results in the subject and a variety of new projects were born. The participants affirmed frequently and spontaneously that the program was a great success.

Workshop on “Singularity, and gradient and Hamiltonian flows,” May 5 – 16, 2008
Organizers: Walter Craig (McMaster), Christiane Rousseau (Montréal), Alexander Schnirelman (Concordia)

The first week was dedicated to a series of three short courses by J.-C. Yoccoz (Collège de France), L. Stolovitch (Toulouse), and R. Montgomery (UCSB), and followed by the workshop. The workshop itself was heterogeneous, with specialists talking on a broad set of themes, whose basis consists of ideas and the philosophy of dynamical systems. The lecture room was in general quite full of CRM visitors, postdoctoral fellows, workshop speakers and their graduate students, as well as mathematicians from the Montréal area. With lively question and answer periods, it was a week full of mathematical interactions.

Short courses: J.-C. Yoccoz gave his lectures in the context of the semester’s André Aisenstadt Chair (see other article).

Laurent Stolovitch’s lectures dealt with the classification of Poisson structures, in the holomorphic and the $\mathbb{C}^\infty$ category. This is the resolution of a program dating from the early 1980s due to A. Weinstein and J. Marsden, giving the classification of singular Poisson structures up to holomorphic (smooth) conjugacy, under a Diophantine condition on the linearization at the singular point. It is surprisingly enough a small divisor problem. Stolovitch went on to discuss the similarity of the problem with the Siegel problem of conjugacy of holomorphic vector fields, and furthermore developed his ideas on extensions of the work to various settings of simultaneous conjugacy of bi-vector fields. R. Montgomery talked on the classification of distributions, discussing the problem of distributions with large growth vector and the construction of prolonging a distribution, and giving an introduction to the theory of Legendrian curves. His talks described the extension of the classical ideas of Cartan by an infinitary suspension method that he termed the ‘friendly monster.’

As for the workshop itself, a number of lectures concerned results on the $n$-body problem and Arnold diffusion. V. Kaloshin, the Clay lecturer for this workshop, gave two lectures on the topic. The first one, a colloquium type talk, discussed special types of solutions of the 3-body problem and their Hausdorff dimension, while the second one presented an example of Arnold diffusion. Concerning the $n$-body problem, S. Terracini discussed collision solutions via variational methods, and K.-C. Chen the stability of satellite solutions. V. Gelfreich described an example of Arnold diffusion in a non integrable billiard. His method can be applied in the more general context of slow-fast Hamiltonians.
P. de Maesschalck gave neat proofs of general theorems for the existence of invariant manifold in analytic or Gevrey class. Moduli spaces of analytic classifications of unfoldings of codimension 1 saddle-node vector fields and parabolic points were discussed by R. Schäfke and C. Rousseau.

Several talks dealt with normal forms near singularities of ODE and PDE and their applications to describe the qualitative behaviour of solutions of PDE of small norms. L. Stolovitch discussed normal forms of singular points of vector fields with non diagonal linear part. Other lectures on the subject were given by D. Bambusi (wave equations) and H. Ito.

F. Dumortier explained conditions on singularly perturbed systems allowing to conclude to the birth of more than one limit cycles when several critical values of the slow curve coalesce. B. Fiedler discussed the global qualitative dynamics of the scalar reaction-advection-diffusion PDE on the unit interval. He showed how the global attractor of the PDE consists of all equilibria and heteroclinic orbits between them.

Dynamical systems methods applied to PDE was a recurrent theme. H. Eliasson and M. Keel discussed Schrödinger equations. M. Keel was concerned with the energy transfer and its growth to infinity in the presence of resonances. E. Wayne discussed the existence of travelling wave solutions of the Fermi–Pasta–Ulam model coming from a pair of counterpropagating waves and ending in such a pair. M. Bialy discussed the periodic solutions of a model of quasi-periodic solutions given by Benney chains, together with a conjecture that all the periodic solutions are standing waves. W. Craig exploited a dynamical systems argument to give new estimates on weak solutions of Navier–Stokes equations, thus yielding nontrivial bounds on the Kolmogorov spectrum of solutions.

An alternative machinery to KAM consisting in using renormalization and universality for Hamiltonian flows was introduced by D. Gaydashev.

A geometric approach to controllability and optimal control of multiparticle system was discussed by A. Sarychev and illustrated on a system of N interacting particles on a straight line.

Organizers: Octav Cornea (Montréal), Leonid Polterovich (Tel Aviv), Felix Schlenk (ULB)

The semester ended beautifully with this huge workshop (68 participants) in May. The main theme of the workshop was symplectic topology and Hamiltonian dynamics. Specific topics covered various homology theories arising in symplectic and contact topology, their algebraic and analytic aspects, applications and ramifications (Abbondandolo, Abouzaid, Bourgeois, Frauenfelder, Ginzburg, Lisi, Oancea, Ostrover, Ono, Salamon, Schwarz), new results on Lagrangian tori (Auroux, Biran, Chekanov, Fukaya), Hofer’s geometry (Karshon, Kerman), rigidity of Poisson brackets (Buhaovsky, Entov), symplectic homogenization (Viterbo), Weinstein conjecture (Albers) and rigidity/flexibility of symplectic embeddings (Hind).

Particularly impressive was Edi Zehnder’s talk about surfaces of section for Reeb flows in dimension three, that started with the work of Poincaré and ended with recent and strong results on closed orbits of Reeb flows. Another touching moment was Guangcun Lu’s lecture on the Conley conjecture in cotangent bundles, that showed that the symplectic community forms a big family over all the world.

The meeting was held in a rather informal and very stimulating atmosphere. The many PhD students helped keeping the meeting lively, and proved that symplectic topology is a very active field of research. They were five talks a day, besides on Wednesday, where the afternoon was left free for discussions.

The many positive comments indicated that the participants were very happy with the conference. They felt that they profitted from the many interesting and carefully presented lectures, as well as from the individual discussions and the opportunities to meet and to collaborate with their colleagues on an international level.

Jean-Christophe Yoccoz
(continued from page 9)

Yoccoz also described the construction of Riemann surfaces built to support a translational flow which can be viewed as suspensions of IEM’s. Their genus plays a major rôle in the complexity of the orbit structure of the problem.

At the level of parameter space, there is a continued fraction algorithm discovered by Rauzy, Veech and Zorich which generalizes the classical Gauss continued fraction algorithm, which corresponds to a renormalization process. The dynamics of this algorithm is hyperbolic and the corresponding Lyapunov exponents have been investigated by Forni, Avila and Viana. This leads to a surprising behavior of the Birkhoff sums of a typical IEM, known as the Zorich phenomenon. The field is at the confluence of complex analysis, dynamical systems, number theory and uses a wide range of techniques.

The last lecture dealt with affine interval exchange maps (AEM) and stressed the similarities and differences with IEMs. The rotation number can be defined for affine interval exchange maps in the same way as it is defined for IEMs. However, while IEMs possess no wandering interval, this is not the case with affine interval exchange maps as shown by Marmi, Moussa, and Yoccoz in 2005: For combinatorial data of genus g > 1, for almost all rotation numbers, and for most slopes, an AEM possesses a wandering interval.

Yoccoz’s lectures were dynamic and clear, and the many attendees appreciated being shown an expert’s overview of this emerging area of low dimensional dynamical systems. We are looking forward to the extension of these results to discontinuous, non necessarily piecewise linear maps of the interval.
**Activités externes et programme général**

**Première rencontre CRM-INRIA-MITACS**

de Michel Delfour (CRM et Université de Montréal)


La collaboration avec le Canada, et en particulier le Québec, se place très haut dans les priorités de l’INRIA dans le domaine des relations internationales. Il y a en ce moment pas moins de 10 équipes associées entre l’INRIA et des équipes de chercheurs canadiens. Un « Memorandum of Understanding for Collaboration » avec MITACS a été signé à Ottawa le 2 juillet 2008 en présence du Premier ministre français F. Fillon et de son homologue canadien S. Harper.

La première rencontre CRM-INRIA-MITACS qui s’est tenue à Montréal du 5 au 9 mai 2008 fut une occasion propice au renforcement des liens et à la création de nouveaux, entre l’INRIA, MITACS, et les instituts canadiens, s’appuyant sur le dossier de coopération entre le CRM et l’INRIA.

Les organisateurs de la rencontre étaient Michel Delfour (CRM et Université de Montréal, président), Yves Bourgault (Université d’Ottawa), Fahima Nekka (MITACS et Université de Montréal) et Marc Thiriet (INRIA et CNRS).

La rencontre était organisée autour de sept thèmes principaux : Systèmes biologiques, cellule, et tissus ; Imagerie et fonctionnalité du cerveau ; Milieux composites, modélisation multiéchelle, optimisation de forme et design ; Cœur ; Dispositifs médicaux implantables, acheminement des médicaments ; Ecoulements physiologiques ; et Système respiratoire. Un des points forts de la rencontre a été la mise en place de bonnes conditions pour créer et faciliter des interactions entre les différents groupes participant à chacun des thèmes ainsi qu’une forte délégation d’étudiants français et canadiens.


**Colloque d’algèbre non commutative**

de Ibrahim Assem (Université Sherbrooke)


L’objectif de ces rencontres est de réunir un groupe varié d’experts de problèmes d’algèbre non commutative qui tous utilisent comme outil essentiel l’algèbre homologique. Le colloque a comporté quatre mini-cours, dans des domaines différents de l’algèbre non commutative, à savoir la K-théorie (M. Karoubi, Université Paris 7), la théorie d’Auslander-Reiten dans une catégorie dérivée (D. Happel, Université de Chemnitz), les identités polynomiales en géométrie non commutative (C. Kassel, CNRS, Université Louis Pasteur, Strasbourg) et enfin la classification des algèbres auto-injectives (A. Skowroński, Université Nicolas Copernic, Toruń).

Parmi les exposés (de 45 ou de 30 minutes), deux lignes de force se sont imposées : d’abord l’étude des relations entre algèbre non commutative et topologie, et ensuite celle des problèmes d’algèbre non commutative qui tous utilisent comme outil essentiel l’algèbre homologique. Le colloque a comporté quatre mini-cours, dans des domaines différents de l’algèbre non commutative, à savoir la K-théorie (M. Karoubi, Université Paris 7), la théorie d’Auslander-Reiten dans une catégorie dérivée (D. Happel, Université de Chemnitz), les identités polynomiales en géométrie non commutative (C. Kassel, CNRS, Université Louis Pasteur, Strasbourg) et enfin la classification des algèbres auto-injectives (A. Skowroński, Université Nicolas Copernic, Toruń).

Le reste des exposés a montré la variété des sujets d’intérêt actuel en algèbre non commutative. La théorie d’Auslander-Reiten, abordée par D. Happel dans son mini-cours, a été l’objet (suite à la page 15)
A Celebration of Raoul Bott’s Legacy in Mathematics

by Robert Kotiuga (Boston University)

This five day conference was held and the CRM on June 9 – 13, 2008. Montreal was a natural venue for such an event since Raoul Bott obtained two degrees in Electrical Engineering at McGill University in the 1940s and an Honorary Doctorate from McGill in 1987. The conference was co-sponsored by the Clay Institute, and partially funded by the NSF. The scientific committee consisted of Sir Michael Atiyah (Edinburgh), Octavian Cornea (Montréal) David Ellwood (Clay Institute), Jacques Hurtubise (McGill), Francois Lalonde (Montréal), David Mumford (Brown), Graeme Segal (Oxford), Stephen Smale (TTI Chicago, UCB Emeritus) Jim Stasheff (Pennsylvania, UNC Emeritus) and Edward Witten (IAS, Princeton). The conference was organised by Robert Kotiuga (Boston University) who is reflecting in this text on Bott’s Legacy and on the conference.

The conference focused on the mathematical legacy of Raoul Bott and the extraordinary impact he had on both topology and interactions between mathematics, physics and technology. The forward-looking event brought together some prominent mathematicians with close connections to him, in order to discuss the emerging fields of mathematics and applications. The following focus topics emerged: Operator algebraic methods, K-theory, Supersymmetry and Quantum Field Theory, Morse theory, string topology, pseudoholomorphic curves, Floer homology, Equivariant cohomology and localization, Generalized cohomology theories and physics, Networks and Modular Forms.

Background

Raoul Bott was a “citizen of the world” in that he was born in Budapest Hungary in 1923, moved to Slovakia soon after, and when he was 16, spent a year in being schooled in England. He then lived in Canada for six years where he obtained two degrees in Electrical Engineering from McGill University, during which time he resolved to become a mathematician. Bott finished a ScD in applied mathematics under Richard Duffin at CMU (which at that time was Carnegie-Tech), with a thesis that solved the most challenging synthesis problems in electrical network theory at that time. A humbling encounter with Herman Weyl landed him an invitation to the IAS at Princeton where, after a few relatively intense transitional years, the application of Morse theory to the problem of computing geodesics on Lie Groups, and the Bott periodicity theorem for the stable homotopy groups of the classical Lie groups, helped metamorphose him into one of the most influential topologists of the 20th century. In a period of about a decade, he was awarded tenure at the University of Michigan and then at Harvard, and among his graduate students, two (Daniel Quillen and Stephen Smale) would eventually be awarded Fields medals for their work in topology. After four decades at Harvard and many more students, he retired to San Diego where he succumbed to lung cancer late in 2005.

The Main Activities of the Conference

We were fortunate to have recruited influential speakers and panelists from three generations in order to cover six decades of Raoul Bott’s research and collectively identify his enduring mathematical legacy. The scientific activities of the conference consisted of two panel sessions, and of twenty-four hours of lectures given by Sir Michael Atiyah (Edinburgh), Paul Baum (Pennsylvania State), James Bernhard (Puget), Octavian Cornea (Montreal), R. Cohen (Stanford), Marco Gualtieri (MIT), James Heitsch (UIC Emeritus; NWU), Nancy Hingston (The College of New Jersey), Morris W. Hirsch (Berkeley), John Hubbard (Cornell), Lisa Jeffrey (Toronto), Nitya Kitchloo
(UC San Diego), Joseph Kohn (Princeton), P. Robert Kotiuga (Boston University), Jim Lambek (McGill), Peter D. Lax (New York University), John Morgan (Columbia), Stephen Smale (Toyota Technological Institute at Chicago), Andras Szenes (Geneva), Constantin Teleman (Edinburgh) Susan Tolman (Urbana-Champaign), Loring Tu (Tufts), Cumrun Vafa (Harvard), Jonathan Weitsman (UC Santa Cruz), Edward Witten, (Institute for Advanced Study).

This provided a unique experience for all involved, and dissemination of the presentations of this conference should prove to be useful to a wide audience. An extended conference proceedings is being prepared, and is expected to appear in 2009 in the series “CRM Proceedings and Lecture Notes” published by the AMS. The volume will be attributed to both the CRM and the CMI.

The masterful presentations of Michael Atiyah and many other senior colleagues could have been anticipated and even expected. The speakers who talked about localization and singularity theory clearly built on the last two decades of Bott’s research. The talks by C. Vafa and E. Witten dwelled on a stream of dualities which quantum field theory has been offering mathematics in recent decades, and the tantalizing new connections to number theory. Many other talks rounded out the conference in other ways. However, there were several unexpected developments where a “big picture” seemed to evolve magically out of smaller parts, and it is useful to focus on one which was not obvious before the conference. Loosely speaking, it pertains to Chas–Sullivan “string topology” and its relation to Floer homology via Morse theory. Here, on one hand, the work of N. Hingston and M. Goersky recast string topology in terms Morse theory as applied to loop spaces by Bott in the 1950s. On the other hand, the works of N. Kitchloo and R. Cohen build on Morse theory in the context of “quantum topology,” and refine the use of Morse theory in low-dimensional topology. In the talks given by these speakers, as well as those of O. Cornea and C. Teleman, one could sense where manifold topology was headed in the next few years, and while many of the new results would be new to Bott, the connection to his mathematical perspective and legacy is inescapable!

Panel sessions were held on the first and last days. The Monday panel session, “Raoul Bott as teacher, mentor, and colleague,” was chaired by Nancy Hingston, and the panelists were Nancy Hingston, Jacques Hurtubise, Nitya Kitchloo, and Susan Tolman. Unfortunately, it would not do justice to the many threads of the discussion if they were summarized in the space available. However, one aspect can easily be related.

In addition to being a profound and influential researcher, it is well known that Bott was a wonderful lecturer. Although this has been documented in many places, the conference has produced some unexpected posthumous testimony! At the end of the Friday panel session, the conference organizer emphasized that the conference was not organized around a mathematical topic but a mathematician, and asked the younger attendees what they thought of the concept. A student who identified himself as a graduate student working in an unrelated field made what was considered a remarkable comment: He said he learnt more at this conference than at mathematics conferences in his area of expertise since speakers at this conference seemed to make an extraordinary effort to communicate their ideas in the simplest and most visual terms possible. What was more remarkable was that the “instant consensus” in the room was that this was a manifestation of all the speakers being influenced by Bott’s lecturing style and his insistence on understanding deep mathematical concepts in the simplest terms possible. Hopefully this ease of communication will be reflected in the extended conference proceedings which are currently in the works.

Colloque d’algèbre non commutative
(suite de la page 13)

des exposés de C. Chaio (Université Nationale de Mar del Plata), F. Coelho (Université de São Paulo), S. Liu (Université de Sherbrooke) et S. Trepode (Université Nationale de Mar del Plata). L’étude des algèbres de Koszul et de Calabi-Yau a occupé les conférences de R. Berger (Université de Saint-Étienne) et de A. Martsinkovsky (Université Northeastern). Des progrès intéressants sur la fameuse conjecture de la dimension fini-tiste due à Bass ont été exposés par O. Mendoza (UNAM) et M. Lanzilotta (Université de la République, Montevideo). La structure multiplicitive des anneaux de cohomologie de Hochschild a été abordée par M. Suárez-Alvarez (Université de Buenos Aires) qui aannoncé la preuve d’une conjecture de Bustamante, et par S. Sanchez-Flores (Université Montpellier 2), qui s’est plutôt intéressée à la structure d’algèbre de Lie de ces anneaux. Des algèbres de Lie apparaissant en théorie de représentations des algèbres ont aussi été l’objet de l’exposé de J. Kosakowska (Université Nicolas Copernic, Toruń). Si on ajoute l’étude des t-structures dans des catégories dérivées (M. Saorín, Université de Murcie), celle des groupes de Coxeter au moyen de modules postprojectifs (M. Kleiner, Université de Syracuse), celle des groupes d’Artin de type fini au moyen de suites exceptionnelles (H. Thomas, Université du Nouveau-Brunswick) et des dégénérations dans les catégories de modules (P. Malicki, Université Nicolas Copernic), on aura un panorama complet de la rencontre.
Le CRM sera l’hôte en 2009 de trois ateliers en neuro-imagerie auxquels s’ajoutera un quatrième dans un nouveau domaine de recherche, l’imagerie dynamique quantique. La modélisation mathématique, le traitement du signal et des images sont des outils indispensables aux quatre ateliers. Les trois premiers seront axés sur l’imagerie de l’activité cérébrale où l’analyse statistique est un élément important. L’imagerie des phénomènes quantiques traite des problèmes pour représenter en image le mouvement des particules quantiques, en particulier, l’électron aux dimensions moléculaires, moins que le nanomètre ($10^{-9}$ m) et l’échelle temporelle de l’attoseconde ($10^{-18}$ s). Les quatre ateliers feront le point sur les mathématiques des modèles dynamiques intrinsèques aux deux disciplines : la neuro-imagerie et l’imagerie quantique.

**Atelier 1 – La modélisation de l’activité neuronale : des petites vers les grandes échelles (17 au 22 août 2009) Organisateurs : F. Lesage, Polytechnique Montréal et CRM ; T. Huppert, Pittsburgh ; H. Benali, Paris 6 et CRM**

L’interprétation des signaux en imagerie fonctionnelle cérébrale (IRMf, spectroscopie RMN, MEG/EEG, imagerie optique diffuse) ne peut faire l’économie d’une modélisation mathématique des processus physiologiques cérébraux. Ces modèles du tissu cérébral relient les différents compartiments de l’électrophysiologie au métabolisme énergétique et à l’hémodynamique. Ils se déclinent sous forme de systèmes d’équations différentielles dont la complexité ne réside pas tant dans leur nombre que leur couplage et leur non-linéarité inhérente. L’atelier fera le point sur ces modèles dynamiques en les confrontant avec les différentes modalités de mesure de l’activité cérébrale.

**Atelier 2 – La résolution de problèmes inverses : approches statistiques, variationnelles et bayésiennes au service de la fusion multimodale (24 au 29 août 2009) Organisateurs : C. Grova, McGill ; S. Baillet, Paris 6 ; J.-M. Lina, ÉTS et CRM**

Dans une représentation distribuée de l’activité cérébrale, la détermination robuste des régions actives et la description de la dynamique de cette activité demeurent un sujet ouvert. L’IRMf est la principale technique d’imagerie qui permet une détection statistique de l’activité cérébrale dans tout le volume cérébral, et par le biais de phénomènes hémodynamique avec une résolution temporelle de l’ordre de la seconde. D’autres techniques d’exploration non invasives permettent d’accéder à une bien meilleure résolution temporelle pour suivre l’activité cérébrale, mais ce au prix de signaux mesurés sur le scalp dont la localisation dans le cerveau nécessite la résolution d’un problème inverse.


Bien que l’analyse multi-échelle en imagerie cérébrale ait été mise de l’avant récemment, elle est implicitement présente dans les travaux précurseurs de Worsley et al. qui sont évoqués dans la session précédente. Dans la session présente, on consièrera la « décomposition atomique » des signaux en termes de fonctions élémentaires (harmoniques, ondelettes, curvelets, …) dans un perspective d’analyse des signaux fonctionnels.

Deux problématiques intéressantes : d’une part, l’analyse microlocale des signaux physiologiques et bioélectriques donne-t-elle une signature de certains processus mesurés en IRM, en EEG, en MEG ou en imagerie optique ? L’estimation par ondelettes est-elle efficace voire utile ?

La seconde problématique porte sur la « représentation sparse » des signaux a l’aide dictionnaires redondants. Dans cette problématique propre à la théorie de l’approximation, le compressive sensing qui permet de relier la question de mesure avec la notion d’information (sujette à la compression) est certainement un secteur des mathématiques appliquées en continuité avec l’héritage des ondelettes. Son application initiale pour l’acquisition rapide et efficace en neuro-imagerie par IRM anticipée certainement des développements et des applications importantes.

Pendant cet atelier, Stéphane Mallat (Polytechnique Paris et Courant Institute, NYU) sera le conférencier de la chaire Aisenstadt.

**Atelier 4 – Imagerie dynamique quantique (19 au 23 octobre 2009) Organisateurs : A. D. Bandrauk (Sherbrooke) ; M. Y. Ivanov (CNRC, Ottawa et Imperial College, UK)**

L’utilisation de la lumière ou des photons pour représenter en image, contrôler et transmettre de l’information moléculaire est un des domaines de recherche les plus significatifs à émerger dans les dernières années. Les spécialités les plus actives de ce domaine incluent l’imagerie temporelle de phénomènes quantiques, la dynamique moléculaire dans l’échelle de temps des femtosecondes ($10^{-15}$) pour le mouvement atomique, ou dans l’échelle de temps des attosecondes ($10^{-18}$) pour le mouvement des électrons. L’étude des phénomènes dans l’échelle des attosecondes est maintenant reconnue internationalement comme l’une des innovations scientifiques les plus importantes du 21e siècle. Un aspect important du développement de l’imagerie ultrarapide temporelle en femto et attosecondes est la théorie et la simulation numérique des réponses non linéaires et non perturbatives des atomes et molécules a des pulsions laser (suite à la page 18)
Data Mining and Mathematical Programming
Panos M. Pardalos and Pierre Hansen, editors

CRM Proceedings & Lecture Notes, volume 45

Data mining aims at finding interesting, useful or profitable information in very large databases. The enormous increase in the size of available scientific and commercial databases (data avalanche) as well as the continuing and exponential growth in performance of present day computers make data mining a very active field. In many cases, the burgeoning volume of data sets has grown so large that it threatens to overwhelm rather than enlighten scientists. Therefore, traditional methods are revised and streamlined, complemented by many new methods to address challenging new problems. Mathematical Programming plays a key role in this endeavor. It helps us to formulate precise objectives (e.g., find a partition, a covering or a hierarchy in clustering). It also provides powerful mathematical tools to build highly performing exact or approximate algorithms.

This book is based on lectures presented at the workshop on “Data Mining and Mathematical Programming” (October 10–13, 2006, Montréal) and will be a valuable scientific source of information to faculty, students, and researchers in optimization, data analysis and data mining, as well as people working in computer science, engineering and applied mathematics.

Contents:
- E. Carrizosa, Support vector machines and distance minimization
- H. Chen and J. Peng, 0–1 semidefinite programming for graph-cut clustering: modelling and approximation
- Z. Csizmadia, P.L. Hammer, and B. Vizvári, Artificial attributes in analyzing biomedical databases
- Y-J. Fan, C. Iyigun, and W.A. Chaovalitwongse, Recent advances in mathematical programming for classification and cluster analysis
- P.G. Georgiev, Nonlinear skeletons of data sets and applications — methods based on subspace clustering
- M.R. Guaraccino, S. Cuciniello, D. Feminiano, G. Toraldo, and P.M. Pardalos, Current classification algorithms for biomedical applications
- G. Kunapuli, K.P. Bennett, J. Hu, and J-S. Pang, Bilevel model selection for support vector machines
- O.L. Mangasarian and E.W. Wild, Nonlinear knowledge in kernel machines
- F. Murtagh, Ultrametric embedding: application to data fingerprinting and to fast data clustering
- O. Seref, O.E. Kundakcioglu, and P.M. Pardalos, Selective linear and nonlinear classification

Anatomy of Integers
Jean-Marie De Koninck, Andrew Granville, and Florian Luca, editors

CRM Proceedings & Lecture Notes, volume 46

The book is mostly devoted to the study of the prime factors of integers, their size and their quantity, to good bounds on the number of integers with different properties (for example, those with only large prime factors) and to the distribution of divisors of integers in a given interval. In particular, various estimates concerning smooth numbers are developed. A large emphasis is put on the study of additive and multiplicative functions as well as various arithmetic functions such as the partition function. More specific topics include the Erdős–Kac theorem, cyclotomic polynomials, combinatorial methods, quadratic forms, zeta functions, Dirichlet series and L-functions. All these create an intimate understanding of the properties of integers and lead to fascinating and unexpected consequences. The volume includes contributions from leading participants in this active area of research, such as Kevin Ford, Carl Pomerance, K. Soundararajan and Gérald Tenenbaum.

Contents:
- V. Blomer, Ternary quadratic forms, and sums of three squares with restricted variables
- R. de la Bretèche, Entiers ayant exactement r diviseurs dans un intervalle donné
- P. Erdős, F. Luca, and C. Pomerance, On the proportion of numbers coprime to a given integer
- K. Ford, Integers with a divisor in (y, 2y]
- H.A. Helfgott, Power-free values, repulsion between points, differing beliefs and the existence of error
- H. Maier, Anatomy of integers and cyclotomic polynomials
- J.-L. Nicolas, Parité des valeurs de la fonction de partition p(n) et anatomie des entiers
- K. Soundararaj, The distribution of smooth numbers in arithmetic progressions
- G. Tenenbaum and J. Wu, Moyennes de certaines fonctions multiplicatives sur les entiers friables
- A. Akbary and M.R. Murty, Uniform distribution of zeros of Dirichlet series
- S. Baier, C.W. Nevans, and F. Saidak, Descartes numbers
- E. Croot, A combinatorial method for developing Lucas sequence identities
- J.-M. De Koninck and F. Luca, On the difference of arithmetic functions at consecutive arguments
- A. Granville and K. Soundararaj, Pretentious multiplicative functions and an inequality for the zeta-function
- R. Khan, On the distribution of o(n)
- W. Kuo and Y.-R. Liu, The Erdős–Kac theorem and its generalizations
- J. Liu, E. Royer, and J. Wu, On a conjecture of Montgomery–Vaughan on extreme values of automorphic L-functions at 1
- N. Ng, The Möbius function
in short intervals; P. Pollack, An explicit approach to hypotheses H for polynomials over a finite field; C.L. Stewart, On prime factors of integers which are sums or shifted products; E.B. Wong, Simultaneous approximation of reals by values of arithmetic functions.

Biology and Mechanics of Blood Flows
Marc Thiriet

Biology and Mechanics of Blood Flows presents the basic knowledge and state-of-the-art techniques necessary to carry out investigations of the cardiovascular system using modeling and simulation. Part I of this two-volume sequence, Biology, addresses the nanoscopic and microscopic scales. The nanoscale corresponds to the scale of biochemical reaction cascades involved in cell adaptation to mechanical stresses among other stimuli. The microscale is the scale of stress-induced tissue remodeling associated with acute or chronic loadings. The cardiovascular system, like any physiological system, has a complicated three-dimensional structure and composition. Its time dependent behavior is regulated, and this complex system has many components. In this authoritative work, the author provides a survey of relevant cell components and processes, with detailed coverage of the electrical and mechanical behaviors of vascular cells, tissues, and organs. Because the behaviors of vascular cells and tissues are tightly coupled to the mechanics of flowing blood, the major features of blood flows and the Navier–Stokes equations of mass and momentum conservation are introduced at the conclusion of this volume. This book will appeal to any biologist, chemist, physicist, or applied mathematician with an interest in the functioning of the cardiovascular system.


Combinatorics on Words
Jean Berstel, Aaron Lauve, Christophe Reutenauer, and Franco V. Saliola

The two parts of this text are based on two series of lectures delivered by Jean Berstel and Christophe Reutenauer in March 2007 at the Centre de recherches mathématiques, Montréal, Canada. Part I represents the first modern and comprehensive exposition of the theory of Christoffel words. Part II presents numerous combinatorial and algorithmic aspects of repetition-free words stemming from the work of Axel Thue—a pioneer in the theory of combinatorics on words.

A beginner to the theory of combinatorics on words will be motivated by the numerous examples, and the large variety of exercises, which make the book unique at this level of exposition. The clean and streamlined exposition and the extensive bibliography will also be appreciated. After reading this book, beginners should be ready to read modern research papers in this rapidly growing field and contribute their own research to its development.

Experienced readers will be interested in the finitary approach to Sturmian words that Christoffel words offer, as well as the novel geometric and algebraic approach chosen for their exposition. They will also appreciate the historical presentation of the Thue–Morse word and its applications, and the novel results on Abelian repetition-free words.


Problèmes mathématiques en imagerie
(suite de la page 16)

ultracourtes. L’imagerie dynamique quantique (IDQ) est donc une nouvelle frontière scientifique requérant de nouvelles avancées mathématiques pour analyser et résoudre certaines EDP multidimensionelles spatiales et temporelles comme les équations de Schrödinger et de Dirac dépendantes du temps et les équations de Maxwell pour les photons dans des effets de propagation collectifs. L’inversion des données expérimentales d’IDQ présente donc de nouveaux défis mathématiques, et les implications pour la recherche et le développement se feront sentir dans des domaines aussi divers que l’optoélectronique, les sciences des matériaux et même l’information quantique, étant donné la propriété de l’IDQ d’être un outil essentiel de contrôle de la matière au niveau moléculaire.
Stagiaires postdoctoraux CRM-ISM 2008-2009

Renouvellements

Bryden Cais (University of Michigan, juin 2007) sous la supervision de Adrian Iovita (Concordia) et Henri Darmon (McGill).
Seung-yeap Lee (University of Chicago, juin 2007) sous la supervision de Marco Bertola et John Harnad (Concordia)
Jeehon Park (Boston University, mai 2007) sous la supervision de Henri Darmon (McGill)
Igor Wigman (Université de Tel Aviv, mai 2006) sous la supervision de Dima Jakobson (McGill), Andrew Granville et Iosif Polterevich (Montréal)

Nouveaux

Nadine Badr (Université Paris-Sud 11, décembre 2007) sous la supervision de Galia Dafni (Concordia)
Norman Do (University of Melbourne, avril 2008) sous la supervision de Jacques Hurtubise (McGill)
Xander Faber (Columbia University, 2008) sous la supervision de Henri Darmon (McGill) et Andrew Granville (Montréal)
Benjamin Young (University of British Columbia, mai 2006) sous la supervision de Jacques Hurtubise (McGill)

Associés à l’année thématique 2008-2009

Robert Buckingham (Duke University, 2005) sous la supervision de Marco Bertola, John Harnad et Dimitri Korotkin (Concordia)
Dong Wang (Brandeis University, 2008) sous la supervision de Marco Bertola, John Harnad et Dimitri Korotkin (Concordia)

Mathematical Aspects of Quantum Chaos

(continued from page 7)

negative curvature necessarily have a positive entropy (hence cannot be completely localized around a single orbit). B. Gutkin (Essen) and S. Brooks (Princeton) managed to strengthen the constraints on the entropy of semiclassical measures for certain families of quantum maps, and show that the obtained bounds are sharp.

Beyond the macroscopic description of the eigenfunctions embodied in Q(U)E theorems, one may focus on the microscopic fluctuations; on such a scale, the eigenfunctions of a quantized chaotic systems are believed to resemble random superpositions of plane waves. One way to measure this “randomness” is to study properties of the nodal sets of the eigenfunctions (that is, the set of points where the functions vanish). The most precise results on this matter require real-analyticity of the system. One is then able to locally represent eigenfunctions by polynomials, and study the nodal sets of the latter. While D. Mangoubi (MPI Bonn) studied the volume of thin “tubes” surrounding the nodal sets on real-analytic manifolds, J. Toth (McGill) counted the open nodal lines for the Dirichlet or Neumann eigenfunctions on real-analytic domains of the plane: their number grows like the square-root of the (very general) Courant bound on the number of nodal domains. For the quasi-1-dimensional case of a quantum graph, G. Berkolaiko (Texas A&‐M) showed a much more precise counting of the nodal points. Some specific manifolds (flat sphere or flat torus) enjoy large spectral degeneracies: it then makes sense to equip the eigenspaces with a certain probability measure, and study the properties of a “typical” or “random” eigenfunction, and compare them with standard models of random superpositions of plane waves. Such a study for the 2-dimensional torus was presented by I. Wigman (CRM): it involves subtle number-theoretic properties.
Mot de la directrice

C’est presqu’au moment de mettre sous presse que j’ai accepté de prendre la direction intérimaire du CRM jusqu’au 31 mai 2009 et ce mot de la directrice sera donc bref. Le CRM est un fleuron de la communauté mathématique canadienne. En témoignent les grandes années thématiques, mais aussi la participation aux grands événements nationaux. Il insuffle un dynamisme à la communauté mathématique québécoise, entre autres par le biais des laboratoires, des ateliers de résolution de problèmes industriels et des activités pour le public.

Ce succès est attribuable en grande partie au travail de titan des directeurs précédents et je profite de ce message pour remercier, au nom de la communauté du CRM, François Lalonde du travail gigantesque qu’il a accompli pendant ses quatre années à la direction du CRM. Je remercie également Anne Bourlioux qui a accepté la direction intérimaire pendant l’été 2008. Anne a accepté de prolonger son mandat au-delà du 31 août, malgré ses nombreux autres engagements pour l’année en cours.

Au-delà du travail des directeurs et directrice précédents, le succès du CRM est également dû au travail et au dévouement de tous les chercheurs, des directeurs et directrices adjoints, et du personnel du CRM.

J’hérite du CRM en pleine santé. Pour la première fois depuis des années nous avons une année thématique plutôt que deux semestres disjointes. Cette année thématique en cours est magnifique. Le thème « Méthodes probabilistes en physique mathématique » rejoint de nombreux chercheurs montréalais qui passent une partie importante de leur temps au CRM. La programmation thématique comprend également un programme conjoint avec le PIMS sur « Les défis et perspectives en probabilités ».


Les discussions des derniers mois ont révélé le dynamisme de la communauté des chercheurs du CRM et la programmation des futures années scientifiques bat son plein. Les projets pan-canadiens ne manquent pas alors que nous sortons d’un congrès Canada-France qui nous a tous réunis et que la communauté mathématique canadienne prépare la candidature de Montréal pour le Congrès international des mathématiciens de 2014. Je me réjouis de travailler avec la communauté du CRM et avec la communauté mathématique canadienne à maintenir la tradition d’excellence des activités du CRM et des mathématiques canadiennes.

Christiane Rousseau

Word of the Director

It is nearly at the time of sending the bulletin to press that I have accepted to become Acting Director of CRM till May 31 2009. Hence this “word of the Director” will be short. The CRM is a success story in Canadian mathematics. This is acknowledged by its thematic years or semesters, and by its participation to large national events. It also lies at the heart of the Québec mathematical community, in particular through its laboratories, industrial problem solving workshops and activities for the public.

This success is greatly due to the gigantic task accomplished by the previous directors. I use this opportunity to thank François Lalonde, in the name of the CRM community, for the great work he did during his four years as Director of CRM. I am also very grateful to Anne Bourlioux who agreed to be Acting Director during the summer and to extend her mandate past August 31, despite numerous other commitments.

Beyond the contribution of previous Directors, the CRM’s success is equally due to the work and commitment of all its researchers, associate Directors and staff members.

The CRM is in great shape. For the first time in several years, we are having a thematic year rather than two disjoint thematic semesters. The current mathematical year is splendid. The theme “Probabilistic methods in mathematical physics” is close to the interests of a number of members from Montreal who spend a significant portion of their time at the CRM. There is also a joint program with PIMS on “Challenges and perspectives in probability.” Four Aisenstadt Chairs lecturers have visited or will visit the CRM in 2008–2009, namely Svante Janson, Andrei Okounkov, Craig Tracy and Wendelin Werner. In parallel, the CRM held two industrial problem solving workshops in 2007 and 2008, and is preparing a third one for 2009. The CRM was a partner in the summer school “Systems Biology Dynamics: from Genes to Organisms” during the summer 2008.

The discussions of the last months have revealed how dynamic the community of CRM members is and the planning of future scientific thematic years is presently very active. Pan-Canadian ventures are numerous: the Canadian mathematical community just ended the Canada–France congress and is now preparing the Canadian bid to hold ICM 2014 in Montréal.

I am looking forward to work with both the CRM and the Canadian mathematical community to maintain the tradition of excellence in the CRM activities and Canadian mathematics.

Christiane Rousseau