FIELDSNOTES

SEPTEMBER 2007 | VOLUME 8:1 FIELDS INSTITUTE Research in Mathematical Science FIELDS

Operator Algebras and Application Fields Institute Thematic Program

July to December 2007

THE THEORY OF OPERATOR ALGEBRAS BEGAN in the early part of the twentieth century at about the same time as quantum mechanics, and is in fact closely related to that subject. However the larger part of the development of operator algebra theory has occurred much more recently.

Eighty years ago, John von Neumann axiomatized Hilbert space, and proved the bicommutant theorem for strong operator closed, self-adjoint algebras of bounded linear operators acting on this space—only shortly after Heisenberg's matrix mechanics, and the equivalent wave mechanics of Schrödinger. Soon afterwards, von Neumann formalized the relation between the two subjects with his monograph, *The Mathematical Foundations of Quantum Mechanics*. At the same time, he vigorously pursued the development of the theory of these algebras of operators (now called von Neumann algebras). This work, which grew to be monumental in scope, was carried out to a considerable extent in collaboration with F. J. Murray. Another collaborator, I. Halperin, worked with von Neumann on the geometrical aspects of operator algebras.

Sixty-five years ago, I. M. Gelfand and M. A. Naimark drew attention to a phenomenon quite outside the sphere of von Neumann algebra theory. A von Neumann algebra, while it may be considered abstractly—as a *-algebra—if desired, has in a rather strong sense a unique Hilbert space representation. (Indeed, it has a

George Elliott

canonical representation, which is said to have multiplicity one, and any other representation is just determined by its multiplicity.) If a self-adjoint algebra of Hilbert space operators is assumed only to be norm closed—to be what is now called a concrete C*-algebra—then in general it has many other, quite different, Hilbert space representations. In quantum mechanical systems with finitely many degrees of freedom, this does not happen. This is illustrated by the unitary equivalence of the Heisenberg and Schrödinger formulation of quantum mechanics, which may be thought of as different, but equivalent, representations of the C*-algebra of compact operators. While this C*-algebra has an essentially unique Hilbert space representation, it was shown in the early 1950s by Gårding and Wightman that the C*-algebra of a system

continued on page 15

WORKSHOP ON STACKS IN GEOMETRY AND TOPOLOGY

THIS WORKSHOP TOOK PLACE AT THE Institute from May 14–18, 2007, and was the final workshop of the Thematic Program on Geometric Applications of Homotopy Theory.

Algebraic stacks first arose in algebraic geometry as a way to describe the symmetries of families of geometric objects, especially when these symmetries do not vary continuously throughout the family. The flexibility of the resulting theory made stacks a useful tool across a wide variety of fields, and the impetus of this workshop was to display these applications in algebraic geometry and algebraic topology. We certainly achieved that aim, but we also caught the wave of the emergence of a remarkable new area of study as well. This area, which might be called derived algebraic geometry, has classical roots in, for example, Serre's work on intersection theory for varieties not in general position, but it has expanded a great deal lately, and the impact of these new ideas was fully on display during the week.

That the study of stacks should lead naturally to derived algebraic geometry is perhaps not surprising: we study stacks up to equivalence – a kind of homotopy equivalence in this setting – and as a result, stacks are inherently derived objects. From this

continued on page 2

Distinguished Lecture Series: Michael Hopkins

THIS SERIES OF THREE LECTURES WAS delivered from May 14–17, 2007 by Michael Hopkins of Harvard University, and discussed topological quantum field theories as generalizations of cobordism theories. The talks were titled *Classical and quantum invariants of manifolds, Homotopy invariance of string topology,* and *The topological WZW space of conformal blocks.*

Generally, classical cobordism invariants take manifolds to abelian groups in such a way that disjoint unions get mapped to direct sums and cobordisms are mapped to identities. A topological quantum field theory associates objects of a symmetric monoidal category (like chain complexes) to manifolds such that disjoint unions are mapped to direct sums, *cobordisms are mapped to homomorphisms*, and certain other axioms are satisfied. According to Hopkins, the most general setup for something like a topological field theory could involve a morphism of higher categories.

The first talk in the series gave this general overview, with examples. The second and third lectures focussed on the problem of how to actually construct a topological field theory, in the standard and equivariant cases respectively.

The second lecture discussed Chas-Sullivan string topology, its open-closed analogue due to Costello, and displayed the method of Hopkins and Lurie for making a topological field theory from an A^∞-algebra (such as cochains on a manifold) with Costello's machinery.

The third lecture discussed work of Freed, Hopkins and Telemann, in which they approximate a topological field theory with a functor defined on moduli spaces of flat connections for some fixed sufficiently nice compact Lie group (the context of Weiss, Zumino and Witten), and taking values in K-theory spectra. Hopkins gave an exposition of Chern-Simons theory, which is usually defined analytically, by using methods from algebraic topology. The result was at once illuminating, in that it isolated the role of the cohomology of classifying spaces, and more general.


Michael Hopkins

The lectures were delivered in a stimulating "discovery" style, which emphasized the historical progression of ideas rather than theorems and proofs.

Rick Jardine (Western)

WORKSHOP ON STACKS IN GEOMETRY AND TOPOLOGY

continued from page 1

to the idea of deriving the stucture sheaves as well is a short step.

Jacob Lurie and Bertrand Toën, two of the leaders in derived algebraic geometry, gave lectures at the beginning and end of the week, respectively, thus providing scientific bookends for the workshop. Lurie's lecture highlighted the role of derived algebraic geometry in developing equivariant cohomology theories and, in particular, equivariant analogs of the Hopkins-Miller theory of topological modular forms. Toën's lecture addressed the problem of developing a notion of smoothness in the derived setting and presented an elegant finiteness result developed from these notions.

The interplay between homotopy theory and geometry was on display throughout the conference. Clark Barwick, for example, used some subtle aspects from the theory of model categories for his spectral algebraic geometry. The development here is that he could do so without comment; until lately, model categories were a tool only for abstract homotopy theorists. Other nice cross-over talks included Mark Behren's talk on topological automorphic forms, bringing Shimura varieties into homotopy theory, and Wendy Lowen's talk on non-commutative spaces via their derived categories. Lowen's talk was mirrored by that of Michel Viquié, who characterized algebraic spaces via their derived categories.

Stacks in more traditional roles featured in a number of talks as well, showing that they give us a powerful tool for applications. Max Leiblich and Angelo Vistoli used stacks in algebraic geometry, Matt Ando used them in algebraic topology, and Chenchang (Sue) Zhu used them in differential geometry.

Concurrently with this workshop, there was a Distinguished Lecture Series by Mike Hopkins. While he could have talked at length about the applications of algebraic stacks in stable homotopy theory, he chose instead to talk about the interactions of algebraic topology, homotopy theory, geometry, and mathematical physics – the main theme was construction and analysis of topological field theories. There were plenty of moduli objects (i.e., stacks) in his talks, but the main topics were slightly different than all the other talks; thus, he was able to tell the audience of new results about familiar objects. Combined with his exploratory and historical style, he ended up telling a very compelling story.

This workshop, as with all cross-field conferences, represented a bit of risk: there is always the question of whether the audience will gel around the topic and whether real cross-over conversation will occur. In this case, we had a remarkable success, demonstrated by the large attendance, spirited conversations, and exciting results.

This workshop was partially supported by a grant from the National Science Foundation (USA), and by the Fields Institute.

Paul Goerss (Northwestern)

The Inaugural Nathan and Beatrice Keyfitz Lecture on Mathematics and the Social Sciences: JOEL E. COHEN


Joel Cohen and Barbara Keyfitz

Perceiving a need for greater public awareness of mathematical and quantitative approaches to the social sciences, the Fields Institute has for some time discussed mounting a public lecture series on *Mathematics and Society*. In these times of environmental uncertainty and rapid political change, assessing the impact of and providing planning advice for social and economic decisions is carried out more and more by means of quantitative models. It is important for the mathematical community, for academic researchers in social sciences and for practitioners in government, social services and industry to obtain an overview of the ways mathematical modelling and quantitative measures are used – to see both their strengths and their limitations.

This project was originally suggested by the statistical advisory committee of Fields (which selects the DLSS lecturers), and was given impetus by a donation from Nathan and Beatrice Keyfitz, which, while not explicitly targeting this need, seems well suited to it. Naming the series for a founder of the discipline of mathematical demography serves as a reminder of one direction in which mathematical modelling has informed social science. The first lecture, held on May 8, 2007, featuring Joel E. Cohen, Professor of Populations at Rockefeller and Columbia Universities, and was a fitting inauguration of the series, as Cohen, whose research spans many different social sciences, chose to speak on the topic of his popular book, *How Many People Can the Earth Support?*

Cohen's talk had a cogent message: There is no answer, because in human society four factors – population, economics, culture and environment – interact to produce the world we live in. In the end, it will be human choices that will determine what that world looks like, how many people are in it, and what sort of life they live. His talk began with an entertaining history of methods that have been used to model the carrying capacity of the earth, covering seven different techniques. He vividly made the point that the models people use to make predictions about the future use mathematics, at various levels, and the untrustworthiness of the models (as shown in many examples) does not reflect on the quality of the mathematics as much as on the specific nature of the assumptions, which are often motivated by political considerations. In an eloquent aside on the inadequacy of the "ecological footprint" approach, Cohen reminded his audience that "Human needs are multidimensional." He ended with the claim that the models are incomplete, and the answers meaningless, without our knowing answers to a number of questions: what level of material well-being do we want, and how do we want it distributed; what levels of technology will we use; what political, economic and demographic arrangements, domestic and international, will we maintain; what ecological environment do we want? How will we choose between variability and stability (for example, in climate change); and how are we prepared to deal with risk? What time horizon are we speaking of; and, finally, how will we weigh our preferences, for example in clothing?

The talk was followed by a reception, at which the capacity audience had a chance to meet the speaker and to ask questions. Interestingly, one question that was asked was, "Where's the math in this?" In a general audience talk, a speaker usually does not go into the details either of modelling or of the mathematical techniques used to answer population questions. Earlier in the day, in a seminar for a mathematical audience, Cohen had outlined in some detail a mathematical question that arose in modelling an ecological system (flour beetle colonies, which experience complicated population dynamics, including cannibalism) whose time evolution contains both nonlinear and stochastic components. Here a conclusion that emerged from numerical simulation was the existence of certain resonances (or spectral peaks). However, developing a mathematical theory that predicts such phenomena, which might be quite general consequences of the interaction of nonlinearity and stochasticity, is an open problem. This example showed how even a well-studied and relatively simple system gives rise to new and interesting mathematical problems.

The Keyfitz Lectures will take place once a year. The second lecture is scheduled for the fall of 2007, with Nevanlinna Prize winner Jon Kleinberg from Cornell as speaker. (*See page 8 for details.*)

Barbara Keyfitz (Fields)

An Elementary and Superficial Introduction to Operator Algebras;
BY KENNETH R. DAVIDSON OF THE UNIVERSITY OF WATERLOO

IT HAS BEEN A TRADITION TO INCLUDE IN each of the Fields Institute Annual General Meetings a talk related to either an upcoming or just finished thematic program. This year Ken Davidson, a past Director of the Fields Institute, presented a talk in his capacity as one of the organizers of the fall 2007 thematic program on *Operator Algebras*. The theme of the talk was the contrast in properties of the familiar finite dimensional Euclidean spaces and their infinite dimensional analogues. These analogues – Hilbert spaces – are the natural setting in which operators can operate.

There are many representations of the separable Hilbert space, but Hilbert himself defined the infinite dimensional, complete linear, inner product space of square summable sequences of complex numbers in 1904. It had only recently become possible to even define the isometric space of square integrable complex functions; Lebesgue had published his dissertation constructing Lebesgue measure and establishing the key properties of the Lebesgue integral in 1902. In 1907 Reisz showed this space to be complete and hence isometric to the space of sequences considered by Hilbert. The notion of an abstract Hilbert space defined axiomatically was introduced by von Neumann in 1927.

The talk began with a review of the key and defining properties of the familiar 3-dimensional Euclidean space, explaining how these can be extended to the infinite dimensional setting. The convergence of Fourier series in measure provides useful concrete examples of the infinite dimensional behaviour in the space of square integrable functions. As an illustration of the unexpected behaviour encountered in infinite dimensional spaces, Davidson posed the following question: *Can a continuous curve be drawn in Hilbert space which is always moving perpendicular to earlier portions of the curve?* Since the question refers to curves that are merely continuous, but not differentiable, a precise formulation asks for a curve such that the lines connecting distinct pairs of points along the curve are perpendicular so long as the two intervals along the curve between those two pairs of points are disjoint. In finite dimensional Euclidean space this is impossible since there is not enough room in k dimensional space to have even k+1 mutually perpendicular lines. However, Hilbert space *does* allow for such exotic behaviour. There is a wrinkled curve which, loosely speaking, moves in a direction perpendicular to all previous directions at any point in time.

The talk went on to describe linear operators on Hilbert space starting from analogies with the finite dimensioncal case. Here again unexpected phenomena arise that are not seen in the finite dimensional case. The unilateral shift on the space of square summable sequences is a source of uniquely infinite dimensional behaviour such as an operator not commuting with its adjoint. With this as a starting point, Davidson went on to motivate the notion of an abstract C*-algebra as defined by Gelfand and Naimark in 1943. Applications of topology through the use of winding numbers and the contractibility of the unit sphere in Hilbert space were also presented.

For many in the audience most of the material presented was more than familiar, but for young mathematicians thinking of working in some branch of functional analysis this was an inspiring and informative talk presented by one of the major figures in the field of operator algebras.

Juris Steprāns (Fields)

MICS TO BE LAUNCHED IN JANUARY 2008

MATHEMATICS-IN-INDUSTRY CASE STUDIES (MICS), a new Fields electronic journal to be launched in January 2008, started accepting submissions in July 2007. MICS aims to meet the publication needs of the burgeoning community of mathematicians who work on problems that are important to industry. Its central theme is the stimulation of innovative mathematics by the modelling and analysis of such problems across the physical, biological and social sciences.

The intensely collaborative nature of industrial mathematics will be reflected in the way MICS attracts and processes papers. The editors-in-chief are John Ockendon (Oxford) and Alistair Fitt (Southampton), two leading figures in the mathematics-in-industry community. The editorial board includes many experienced researchers who are regularly involved in industrial problem-solving around the world. This will enable them to proactively encourage rapid publication of appropriate case studies. MICS will also accept and publish unsolicited submissions and it is planned that strong alliances with relevant websites and newsletters will create natural channels for such submissions.

Although MICS has been conceived as the result of the vibrant Canadian culture of mathematics-in-industry, it intends to publish contributions from around the world, highlighting the commonality of key methodologies and pinpointing areas where mathematical creativity will have the most impact.

The idea of MICS started when Bradd Hart was the acting director of Fields and it was through the help of many people over the past several years, including Tom Salisbury (former deputy director of Fields), Juris Steprans (current deputy director of Fields) Robert Miura (NJIT), Pam Cook (Delaware), Nilima Nigam (McGill), and most importantly through the support of Barbara Keyfitz, current director of Fields and the hard work of Fields staff (Alison Conway, Richard

continued on page 16

PROBABILITY AND STOCHASTIC PROCESSES SYMPOSIUM

in Honour of Donald A. Dawson's Work, on the Occasion of his 70th Birthday

Don Dawson's keynote lecture, *Reflections on probability and stochastic processes 1957-2007,* held at Carleton University on June 5-8, 2007, gave an exciting, personal perspective on developments in the field of probability over the last half century, in particular, how it grew to become a very diverse and mature part of mathematics. Probability started out barely recognized as an important part of pure mathematics, and now has seen profound theoretical advances. As Don pointed out, this has largely been due to stimulating difficult problems coming from applications, such as physics and biology. Of particular interest was the second part of Don's presentation that addressed probabilistic models in biology, with emphasis on recent progress on emergence of rare mutants.

The meeting drew a large number of participants (58), many of them graduate students and postdoctoral fellows. Many of the talks in the conference centred around spatial branching models and superprocesses, bringing the audience up-to-date on recent developments in this area. But in fact, the range of topics reflected Don's own broad interests, ranging from finance and genetics to queueing theory and statistical mechanics. Seeing as the symposium was in his honour, the organizers assigned Don the task of introducing each and every speaker, a duty he discharged with warmth and good humour.

Don is one of the world's leading probabilists, and the meeting provided an occasion to celebrate his many accomplishments. His seminal work on spatially distributed stochastic processes and infinite-dimensional branching systems has had a major impact on the theory of probability. Superprocesses (such as the well-known Dawson-Watanabe process) form an important class of infinite-dimensional diffusion processes, playing a role analogous to that of Brownian motion in stochastic analysis. Not only do they allow one to model biological populations that migrate over time, or the evolution of genotypes within a population, but they are prototypical examples of solutions to stochastic partial differential equations (SPDEs). As with Brownian motion and the heat equation, they give rise naturally to PDEs. But now the equations in question are nonlinear. Moreover they have links to questions of critical phenomena and universality, from statistical physics – for example they arise in the study of percolation's "incipient infinite cluster".

Symposium Participants

> "the range of topics reflected Don's own broad interests, ranging from finance and genetics to queueing theory and statistical mechanics"

Don's influence on Canadian mathematics has been profound. His many former graduate students, a number of whom spoke at the symposium, can be found in departments across the country. Don is currently Professor Emeritus, and Distinguished Research Professor at Carleton University. He served as Director of the Fields Institute from 1996 to 2000, with his leadership at Fields contributing to the founding of MITACS, as well as to the establishment of stable funding for PIMS. Among his many other achievements, in 2004 he won (what was then called) the CRM-Fields prize. He has served as co-editor-in-chief of the Canadian Journal of Mathematics, and has given both the Fields Distinguished Lecture Series in Statistical Science and the CMS's Jeffrey-Williams Lecture. Recently he completed a term as President of the Bernoulli Society for Mathematical Statistics and Probability.

The symposium was sponsored by the Fields Institute, le Centre de recherches mathématiques, the Laboratory for Research in Statistics and Probability, and Carleton University.

Antal A. Járai (Carleton), Tom Salisbury (York)

LATTICES AND TRAJECTORIES: A Symposium of Mathematical Chemistry in Honour of Ray Kapral and Stu Whittington

Ray Kapral and Stu Whittington were born within a few days of each other (in the US and the UK, respectively). They both spent their whole professorial lives as leading members of the Chemical Physics Theory Group, in the University of Toronto, Department of Chemistry. Both have made use of both analytical and computational techniques. Both have year after year made outstanding contributions to many aspects of basic theory in statistical mechanics, and both have been inspirations and good friends to each other and to those around them. After such parallel distinguished careers, it seemed only suitable to have a joint celebration of their both turning 65, and have that celebration centre around an international symposium bringing together many of the most active people in the several fields the two of them have pioneered.

The Symposium that resulted at the Fields Institute from May 31–June 2, 2007, was lively and scientifically exciting, attracting sixty-odd participants from all over the world. The title *Lattices and Trajectories* reflects principal themes in the work of each honoree: much of Stu's work has centred on lattice models for understanding the behaviour of polymers, including DNA; much of Ray's on ways of examining the trajectories of many-body systems with a view to understanding the kinetics of chemical and physical processes. The talks, most of which were given by speakers either current or former collaborators of Ray or Stu, fell naturally into two groups associated with the themes of one or the other: in the program, the two groups of papers were systematically intermixed, which kept us on our toes! The talks also formed a satisfying mix of reviews of advances in the fields and announcements of new investigations. In all we heard 28 talks by distinguished scientists, some 15 of which were long presentations, and the remainder shorter research reports. The "lattice" papers paid particular attention to force-induced extension or unfolding of polymers, to knots and unknotting in polymers, and to the new features that arise for copolymers – all currently exciting topics to which Stu has made seminal contributions. Recent work on understanding polymer phase transitions was reviewed. Neal Madras reviewed the different features that arise if one considers non-Euclidean lattices, and in particular hyperbolic lattices; we were also told of a simple counting problem on a lattice which mysteriously leads, in a continuum limit, to the Dirac equation! It would be hard to summarise briefly the extreme variety of the remaining talks, which revolved around aspects of the dynamics of many-body systems. Many concerned pattern formation or self-organisation, others turbulence, chaos or quantum decoherence; more than one were concerned with cardiac arrythmias. Oppo pointed out many analogies between fluid phenomena and those in photonic systems – which display similar patterns but of course have different names. Ciccotti gave a beautiful description of his new approach to finding microscopic minimum-free-energy paths for chemical processes – though we never really solved the question of how many t's there ought to be in "committor"! Particularly exhilarating was Chate's paper on the dynamic behaviour of the collective motion of very minimal models of interacting active or self-propelled particles, and its relationship to flock behaviour in birds or other animals, among other things. In short, a most satisfying three days of mathematical science.

Papers based on the talks given in the Symposium are to be published together, in a special commemorative issue of the *Journal of Mathematical Chemistry*.

Meanwhile, the event was meant to be a birthday party as well as a scientific meeting! On the first evening (May 31) the Chemistry Department hosted a reception for the Symposium attendees, as well as many of Ray's and Stu's friends within the Chemistry Department. On the following evening we were treated to a magnificent concert featuring the outstanding young violinist Catherine Mamoukian, and Christopher Burton on the piano, playing Brahms's Sonata No. 2 (Opus 100) and Cesar Franck's Sonata in A Major (No. 322). The final night brought a celebratory banquet, held in the Great Hall of Hart House. The dinner was followed by volunteered remarks from a great many of those attending the Symposium – indeed this went on 'til nearly midnight – in which they recounted amusing anecdotes involving Stu and/or Ray, or simply expressed appreciation of the contributions they had made to so many. Tony Guttmann, Giovanni Ciccotti and Frank den Hollander made especially considered contributions. Stu's son Graeme and Ray's son Michal both made amusing but moving remarks. But the highlight of the evening must be assigned to David Coker's contribution: he and his wife had actually written a short near-murder mystery, set in the context of the Symposium and involving the Ciccottis (Giovanni was the near-victim), the Kaprals, the Whittingtons, the Valleaus and the Schofields, the Chancellor of the University, and others. David didn't merely read this out, but satirically impersonated the characters as he went – a tour de force! A spectacular finish to a splendid event, both scientific and social.

"talks given in the Symposium are to be published together, in a special commemorative issue of the *Journal of Mathematical Chemistry*."

John Valleau (Toronto)

SUMMER SCHOOL IN IWASAWA THEORY

The vast majority of the 75 participants at the summer school held at McMaster from August 9–13, 2007 were PhD students who had come from around the world to learn about this central and rapidly developing area in algebraic number theory. Four of the world's leading experts gave lecture series designed to introduce students to the basics of the theory as well as to some of its most current developments.

Iwasawa theory originated in the 1950-1970's in papers of Kenkichi Iwasawa, who studied the growth of class groups in towers of cyclic extensions of number fields. These class groups measure how far the ring of integers of such a finite extension of the rationals is from being a principal ideal domain. Iwasawa was especially interested in the structure of the p-parts of these class groups as modules over the Galois groups of the finite extensions in the tower in the case in which the order of these groups is a power of a prime p. Ralph Greenberg of the University of Washington delivered a series of lectures introducing the audience to these foundational aspects of the subject.

Today, Iwasawa theory concerns itself as well with the growth of interesting objects arising from arithmetic geometry, such as Selmer groups of elliptic curves. The "main conjecture" posits a relationship between the growth of such objects in towers, with analytic objects called p-adic L-functions, in analogy to a statement for class groups of cyclotomic fields proven by Barry Mazur and Andrew Wiles in the 1980's. Robert Pollack of Boston University gave a lecture series on the Iwasawa theory of elliptic curves.

Much of the current interest in Iwasawa theory is in understanding the growth of class groups and Selmer groups in non-abelian towers of number fields. Known as non-commutative Iwasawa theory, this fascinating and intricate subject has its own main conjectures, in which the p-adic L-functions are still in general only conjectural. John Coates of Cambridge University gave a lecture series on the foundations of this subject.

Iwasawa Participants

One of the most promising and important recent developments in Iwasawa theory is the extension of the techniques of Mazur and Wiles to study the structure of Selmer groups of elliptic curves, using four-dimensional Galois representations. Eric Urban of Columbia University gave a lecture series that first outlined the proof of the classical main conjecture and then of his recent work with Christopher Skinner on elliptic curves.

> "Iwasawa theory concerns itself as well with the growth of interesting objects arising from arithmetic geometry…"

In our opinion, however, the highlight of the summer school was not the speakers, but the students. They had come from all over the world: Canada, the United States, Europe, and from as far away as India and Japan, to learn about Iwasawa theory. In many cases, their advisors and departments generously supplemented funding from the Fields Institute and the National Science Foundation to help make it possible for them to come. This summer school was to be about the students, to introduce them to the subject and give them a foundation that should serve them well in their future mathematical careers.

For each of the lecture series, students worked in groups with the speaker on a related project. The students worked on these projects in four intense late night sessions, to which the speakers generously donated their time and energy. By the third session, all of the students were staying to work on their projects long after the sessions ended at 10pm. On the final morning of the conference, a number of the students got their chance to deliver short lectures to the audience on a part of the project the group had completed. Their results were not only impressive, but informative, nicely complementing the speakers' lecture series.

Romyar Sharifi, Manfred Kolster (McMaster), and William McCallum (Arizona)

Workshop on the Mathematics of Evolution: Adaptive Dynamics in Theory and Practice

The theory of adaptive dynamics (AD) was developed in the 1990s by Dieckmann, Geritz, Metz, Law and others to explain the evolution of certain traits in a population according to ecological interactions. The theory has since received a lot of attention by mathematicians and modelers but also some criticism from geneticists and experimentalists who question the simplifying assumptions and seek specific predictions to test. The goal of the workshop was to bring together mathematicians and experimentalists to bridge some of the gaps between theory and application. This goal was reflected in the organizing team that consisted of two mathematicians, F. Lutscher, V. LeBlanc (both University of Ottawa), and two biologists, R. Kassen (Ottawa) and T. Sherratt (Carleton).

This workshop ran from May 7–9, 2007 at the University of Ottawa, and was the first conference in North America dedicated exclusively to AD. The 38 participants came from Canada, the US and Europe. The first day focused on the most recent theoretical results with invited talks by M. Doebeli (UBC) and P. Taylor (Queens) with several contributed talks presenting novel results on adaptive dynamics in space, evolution of virulence, and phenotype determination. The second day focused on new experimental results about evolution with invited presentations by M. Ackermann (ETH Zurich) and L. Wahl (Western), and several contributed talks presented evidence of disruptive selection and coevolution in experimental systems. The last day started with an invited talk by R. Law (York, UK), outlining several future challenges to unite AD with research in evolution and genetics. Several contributed talks presented novel approaches in stochastic theory and partial differential equations as extensions and alternatives to AD.

The workshop schedule allowed for many informal discussions, e.g. over lunch and during the reception on the first evening. Participants enjoyed these discussions as much as they did the lectures that were all very well presented. Students and postdoctoral fellows were excited to meet some of the leading researchers in the field, who in turn were inspired by the younger generation and their enthusiasm. The following quotes from participants summarize the overall atmosphere:

"Thanks for organizing this workshop, it was fantastic: great talks, great people with positive interactions. Everything was well taken care of, from the first morning to the end, refreshments, lunch, etc."

"We had a great time hearing other people's research and communicating ours."

Adaptive Dynamics participants

"Just wanted to thank you all for putting on such an excellent conference. I enjoyed it greatly. "

Interdisciplinary communication is not always easy, but this excellent workshop achieved its goal to build new bridges between people and disciplines.

Frithjof Lutscher (Ottawa)

FIELDS

NATHAN & BEATRICE KEYFITZ PUBLIC LECTURES IN MATHEMATICS & SOCIAL SCIENCES

TUESDAY OCTOBER 30, 2007 – 6:00PM
KOFFLER INSTITUTE, 569 SPADINA AVENUE, ROOM KP 108

Speaker: Jon Kleinberg
Professor of Computer Science, Cornell University

THE GEOGRAPHY OF SOCIAL INFORMATION NETWORKS

The rapid evolution of the on-line world over the past decade represents a blending of social and technological networks, and it is changing the ways in which we interact with information and with each other. It is also the leading edge of a revolution in measurement, with the digital traces of on-line interaction enabling the study of social processes at unprecedented levels of scale and resolution. Making sense of this kind of data, and using it to shape the networks we inhabit, raise many new questions — among them, how to synthesize information when there are a billion sources providing it; how to reason about privacy in a world where almost every transaction is recorded; and how to develop the scientific principles that can relate individual behavior to global properties of large populations. The resulting challenges require new ideas in mathematics, computing, and the social sciences, and point to opportunities at the emerging interface of these disciplines.

www.fields.utoronto.ca/programs/scientific/keyfitz_lectures/ kleinberg.html

CANADIAN OPERATOR SYMPOSIUM (COSy)

COSy Participants

The 35th Canadian Operator Symposium (COSy), held at the University of Guelph from June 5-9, 2007, included an informal tribute to Israel Halperin, who founded COSy in 1972. Professor Halperin died in March of 2007 after a long (he was 96) and remarkable life. At the conference banquet many of the older participants recalled the influence of Halperin on their mathematics and on their more general worldview. Former students and colleagues John Holbrook, George Elliott (Toronto), and Peter Rosenthal (Toronto) spoke at some length.

Israel Halperin was a powerful and prolific mathematician, and a teacher who transformed the lives of many of his students. In his classes they seemed to see mathematics being created right before their eyes, with their own ideas somehow playing a role. Halperin, who interestingly was the only doctoral student of John von Neumann, was a primal force in the development of Canadian mathematics, especially in the areas of operator theory and operator algebras. In parallel with all that, he worked for human rights with a tireless determination. Falsely accused of espionage in the aftermath of the Gouzenko affair, he was held incommunicado for some time by the federal authorities. Although he later deflected any discussion of this episode, one may suppose that his own experience with injustice explained, in part, his passionate defence of the rights of others. Numerous awards, including the Order of Canada, recognized Israel Halperin's service to society as well as his scientific work.

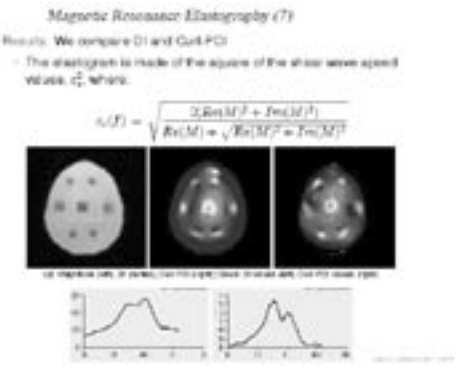
continued on page 16

WORKSHOP ON BRAIN BIOMECHANICS

Mathematical Modelling of Hydrocephalus and Syringomyelia

The purpose of the meeting, held on July 27, 2007, was to review the current state of the field, report on recent progress and chart new directions for research in this interdisciplinary field. The assembled company read like a who's-who of leaders in the field. In addition, the organisers made a concerted effort to invite leading researchers (both experimentalists and theoreticians) not traditionally associated with research in hydrocephalus and syringomyelia, in the hope that this would lead to an infusion of new ideas and fresh perspectives on the theoretical and experimental problems encountered in the field. As a result, there was much spirited debate and several novel mechanisms proposed for the development of hydrocephalus and syringomyelia research. (One junior participant remarked that it was "...inspiring to see such lively debate and realise that experts in the field are not always in agreement with each other!"

A number of the talks focussed on the role of pulsatility in the etiology and



development of hydrocephalus, others on possible mechanisms that could explain the onset of normal pressure hydrocephalus. There were also several presentations on more sophisticated mathematical and computational frameworks in which to model both hydrocephalus and syringomyelia. There was widepread agreement among the participants that the meeting had been highly productive, focussing as it did on critical issues that are currently under active debate in the research literature. In addition, the general feeling was that the workshop raised important questions that will hopefully lead to significant advances and progress in the field. Junior participants reported that the meeting had been highly informative and lively, and that although they had approached the meeting with some trepidation (given that it was scheduled from 8am - 6:30pm), in fact, they didn't notice the time fly by until the meeting concluded just short of 7pm!

We would be remiss not to thank the Fields Institute for hosting the meeting and ensuring that it ran so smoothly. We are indebted to Curt Stewart and the Brain Child Foundation for providing substantial funding that contributed, in no small measure, to the great success of the meeting. It appears, from numerous enquiries from participants and invited speakers, that they are eagerly awaiting the sequel "Brain Biomechnics II".

Siv Sivaloganathan (Waterloo and CMM)

International Symposium for Symbolic and Algebraic Computation (ISSAC 2007)

George Labahn, Barbara Keyfitz, William (Velvel) Kahan, and Keith Geddes

On July 29 the University of Waterloo was the site of this year's International Symposium for Symbolic and Algebraic Computation (ISSAC). ISSAC is the premier international conference in computer algebra, with the 2006 conference held at Genoa, Italy and the 2008 and 2009 events scheduled to occur in Linz, Austria and Seoul, Korea, respectively.

ISSAC 2007 was very successful, attracting nearly 200 computer algebra researchers from around the world. The attendance was the largest for the past 15 years of ISSAC.

This year's event consisted of a day of tutorials followed by three days of talks, software demonstrations and poster sessions. For the first time in approximately 10 years there were parallel sessions for the contributed talks. This ensured that there was plenty of time available for discussion amongst participants and for viewing poster presentations.

The first day consisted of three diverse tutorials on differential equations, algebraic geometry and symbolic linear algebra. Tutorial attendance was also at record levels, with some of the tutorials having more than 70 attendees. The day began with the tutorial by Fritz Schwarz (Fraunhofer Institut), titled *Loewy Decomposition of Linear Differential Equations*. The goal was to give students and researchers an introduction to techniques for working with rings of differential operators (ordinary and partial), their ideals and their decompositions. Tools for such techniques come from differential algebra and factorization of operators.

The second tutorial, by David Cox (Amherst College) was on the topic of Gröbner bases, a central tool used for working with multivariate polynomial systems and polynomial ideals. The tutorial gave a short, but detailed, introduction to Gröbner bases, including concepts such as monomial orderings and consistency theorems. This was followed by information about the use of Gröbner bases in the geometry of elimination and then a discussion of recent developments and applications of these polynomial ideal bases. This tutorial was particularly well received with one of the big draws being David Cox, the author (with Little and O'Shea) of the book *Ideals, Varieties and Algorithms*, recognized as the introductory yet fundamental textbook in computational algebraic geometry.

The last tutorial, by Gilles Villard (École Normale Supérieure de Lyon) presented recent progress in the area of Symbolic Linear Algebra. Of particular note was information presented about the improvement of complexity estimates for fundamental problems such as linear system solution, determinant, inversion and computation of canonical forms. Villard showed how these improvements could be used in the construction of new, effective algorithms for use in high performance linear algebra libraries. Some of the results themselves were illustrated by showing computations done in the LinBox, a C++ high performance linear algebra library.

> "Kahan emphasized the need for careful error analysis in numerical computation…"

The conference had three invited talks, with the intent being to cover areas important for computational mathematics that come from both inside and outside the main recognized areas of computer algebra. The first talk was presented by William (Velvel) Kahan (UC Berkeley). Kahan is a Canadian who was awarded a Turing award in 1989 for his work on IEEE arithmetic. In his talk, Kahan emphasized the need for careful error analysis in numerical computation but also noted the lack of available expertise available to do such tasks. He pointed to the disappearance of floating point error analysis in today's undergraduate and

graduate curriculums as the main cause of this shortage of expertise. He challenged compiler researchers in programming languages and compilers to provide tools that would help with the analysis of floating point computations.

The invited talk by Jean Bernard Lasserre (CNRS), discussed the problem of numerical computation of the real radical of a system of polynomial equations. There are several symbolic approaches to computing the real solutions of such systems. The interesting and original approach presented by Lasserre resorted to techniques developed in the realm of algebraic optimization. In this case, nonlinear optimization on a convex set is reduced to semi-definite programming through representation theorems in real algebraic geometry, involving sums of squares or moment matrices. These are then combined with relaxation techniques introduced by Lasserre. The talk was an excellent illustration of the interconnection of algebra and computations, even in a numerical setting.

The final invited talk was given by Hoon Hong (NCSU, North Carolina) on the topic of subresultants and their generalizations. Subresultants are standard tools used in computer algebra for working with greatest common divisors of polynomials or roots of polynomials. Hong illustrated the use of this tool and showed his attempts at capturing the elegance of their use but with alternate descriptions of the polynomials, in particular when they are defined in terms of their roots. Work on generalizations to a multivariate setting was also presented.

In addition to the tutorials and invited talks, there were 50 research papers presented at the conference. These papers were thoroughly refereed (indeed each accepted paper had at least 3 reviews). The best paper award was given to *A recipe for symbolic geometric computing: long geometric product* by Hongbo Li of the Chinese Academy of Sciences. The best student paper of the conference award was presented to Marc Dohm of the University of Nice for his paper *Implicitization of bi-homogeneous parametrizations of algebraic surfaces via linear syzygies* (with Laurent Busé).Both awards are sponsored by ACM/SIGSAM. Another conference talk that should be mentioned is *Towards the optimal bound for solutions to Rubik's Cube* by Dan Kunkel and Gene Cooperman. The talk showed that it is always possible to solve the Cubic Rubik puzzle in at most 26 moves no matter where one starts. The procedure, which makes careful use of computing science combined with group theory to find all possible successful paths, caught the attention of numerous outside press agencies, ranging from local newspapers all the way to the BBC.

George Labahn (Waterloo)

Workshop on Perspectives for Future Directions in Computational and Mathematical Neuroscience

JULY 7 WAS AN IDEAL DATE FOR THE WORKshop – it was the day before the 16th annual Computational Neuroscience meeting, which also took place in Toronto (first time in Canada). One of us (Frances Skinner) was the local organizer of that meeting. This helped us to piggy-back off the big meeting in terms of speakers and participants.

Computational neuroscience seeks to understand how the brain and nervous system compute. This is a highly interdisciplinary field thus making it somewhat difficult to navigate and to understand where and how one might be able to fit in. The goal of our workshop was to obtain perspectives for future directions in the field. The workshop was a somewhat unorthodox one; it was designed to stimulate discussion and networking, rather than being primarily a venue for research talks.

The morning portion of the workshop featured six half-hour talks by well-established practitioners in the area: Sue Becker (McMaster), Ron Calabrese (Emory) Doug Crawford (York), André Longtin (Ottawa), Jon Rubin (Pittsburgh), and Hugh Wilson (York). They were chosen to represent a wide range of research views, from the top-down view of theoretical neuroscience to the hard reality of experimental neuroscience, and the range of methodologies in between (biophysics, data modelling, deterministic models, models with noise).

In addition to describing their own research highlights in the field, the speakers were asked to provide their opinions and insights on how they defined the field, what they thought were critical considerations for someone wanting to enter the field today, what they thought were ideal types of training, and what they would suggest for changes and directions in the field.

These short talks were followed by a quick lunch and then a series of afternoon discussions. We divided up the six speakers from the morning sessions among the two seminar rooms on the second floor and the library on the third floor. The participants broke up into three groups, with each group going off to visit two of the morning's speakers. After a discussion of 30-40 minutes, the groups rotated to the next pair of speakers and so on. In this way, the participants were able to have group discussions with the speakers and with one another. After these discussions, we all joined up again to compare notes.

Some of the results of the talks and group discussions are the following. It was universally felt that more synergy and better communication between theory and experiment are needed, as well as mutual appreciation between

continued on page 16

FIELDS INSTITUTE Summer Workshop on Environmetrics

The Fields Institute Summer Workshop on Environmetrics was held at Waterlooo on July 17–19, 2007. The aims set out by the workshop organizers were:

- To raise awareness and interest of environmental scientists and statisticians – particularly those from North America – about environmetrics.
- To join forces and integrate the expertise of the above groups.
- To generate interest about and explore the creation of a graduate program in environmetrics in Central-Eastern Canada.

We were very pleased with the outcome since all the conference objectives were fully met. The following is a summary of the workshop participation and activities.

The workshop was attended by 25 statisticians, biologists and ecologists from academia, 15 leading scientists from government agencies and research centres, 5 participants from the private sector, and 40 graduate students

The workshop attracted nearly 90 registrants from Canada, the United States, the Middle East and Africa. Many were statisticians, biologists and ecologists from academia, and included professors and graduate and undergraduate students. Scientists from several government agencies, research centres and private organizations were also present.

Environmetrics Participants

Day 1 was dedicated to raising awareness of environmental statistics by holding several presentations on why and how statistics is integrated into environmental research, and by discussing a rich variety of popular statistical methodologies used in environmental research.

> "the creation of a graduate program in environmetrics in Central-Eastern Canada"

Day 2 focused on overcoming the challenges encountered in doing environmental research, with several presentations ranging from addressing obstacles noted by the participants that hinder this work, to issues of funding. The day concluded with two multimedia shows on very exciting emerging research areas in environmetrics.

On Day 3 we addressed the issues of desirability, feasibility and structure of a graduate program in environmetrics. The audience was enthusiastic about the initiative – the model with the strongest support being the housing of the program in a university with strong statistics and environmental sciences programs, and having collaborations with other universities and scientists from government agencies and research centres.

The participants formed a diverse audience. It was refreshing to witness the high interest shown by the students, and the influential role played by some of the participants, including the President of the International Environmetrics Society and two editors of leading international journals on environmetrics. Interactions between the speakers and audience took place throughout the workshop.

Grace Chiu (Waterloo)

UNCONVENTIONAL COMPUTATION 2007

Queen's School of Computing hosted the Sixth International Conference on Unconventional Computation, UC'07. The conference took place at the Four Points Sheraton in Kingston, Ontario's beautiful downtown core, August 13-17, 2007. The conference was held to discuss ideas of computation that surpass the traditional Turing model.

Participants of UC'07 began to arrive Sunday night from various universities and industries that collectively spanned six continents. After a pleasant social gathering Sunday night, the conference began bright and early Monday morning with a talk from Michael Arbib (Southern California) on the continuing unconventionality of neural computing. Arbib's notion of persistent and dynamic unconventionality set the tone for the conference. Ideas from diverse disciplines were presented as inspiration for various computational algorithms. For example, Monday afternoon saw many new and novel concepts, as open problems in the field of unconventional computations were presented.

Tuesday oriented itself towards quantum physics and how it lends itself to computation. Gilles Brassard (Montreal) gave a tutorial on quantum information processing in the afternoon, after a morning of heated debates on how information is best categorized and utilized. Wednesday's subject matter grew from nature's evolving wisdom. Roel Vertegaal (Queen's) gave a presentation on creat-

continued on page 13

JUMPing Across the Pond

JUMP is a not-for-profit charity that provides professional development and materials to teachers of elementary and intermediate mathematics. Over the past year the Fields Institute has hosted JUMP training and information sessions for several hundred teachers, tutors and parents.

In the summer of 2006, the Lambeth school board in London England ran a two month pilot in over twenty elementary schools using the JUMP materials and methods. Teachers involved in the pilot reported great improvements in student behaviour, attitude and academic performance. In the words of one teacher:

"From being easily defeated mathematicians who rely heavily on adult support, these children are now 'ballsy' independent learners, full of confidence, desperate to show off their skills and love of math."

Inspired by the success of the pilot, the board implemented the JUMP program in over thirty schools for a full academic year. At the end of the year a significant number of students who were initially not expected to meet grade level on the national standardized math exams did so, with many students advancing three to five grade levels in a single year. The board has let JUMP know how pleased they are with the results, and have hired a math consultant to work with JUMP staff to support new implementations of the program this year.

JUMP has had some notable successes in Canada this year too. JUMP staff trained over a hundred teachers in the Vancouver school board: many of these teachers have sent JUMP enthusiastic testimonials on the effects of the program in their classrooms, and many have formed study groups and support groups to introduce new teachers to the program. Owing to the success of the program and the enthusiasm of the teachers, the school board has selected one of its teachers to be a JUMP consultant in the board. JUMP has also been asked to provide professional development to the entire Howe Sound school board, directly north of Vancouver, and has trained over 50 First Nations teachers in BC.

In the spring of 2007, JUMP formed a partnership with a team of doctors and cognitive scientists from the Hospital for Sick Children and the University of Toronto to document the effects of the program. A research pilot project designed by the team will start this academic year in the Toronto Catholic school board. As well, educational researchers at OISE and UBC will launch a second research pilot in Vancouver to study how JUMP contributes to teachers' knowledge of mathematics.

> "many have formed study groups and support groups to introduce new teachers to the program"

John Mighton with students

More information on the results of the Lambeth pilot and other JUMP initiatives can be found at the JUMP website at www.jumpmath.org.

John Mighton (JUMP Founder)

UNCONVENTIONAL COMPUTATION

continued from page 12

ing user-interfaces that are harmonious with their environment. This was followed by a workshop on biologically inspired computations. Lila Kari (Western) began Thursday by lecturing on self-assembly in nanocomputation systems. Problems and challenges in ad hoc and sensor networks were presented in the afternoon by Hossam Hassanein (Queen's). The day closed with a friendly banquet accompanied by a jazz quartet, where animated discussion was a hallmark of the night.

UC 2007

Tal Mor (*Technion—Israel Institute of Technology*) furthered consideration of quantum computing when he presented his work on algorithmic cooling. UC'07 closed Friday on a lively note when the floor was opened for discussion on the week's presentations. In tune with the week, ideas were exchanged on the exact nature and power of computations – despite the various inputs, no universally accepted answer was computed.

Selim Akl (Queen's)

CANADAM 2007, *The First Canadian Discrete and Algorithmic Mathematics Conference*

CANADAM 2007 Participants

Suppose you hosted a conference and nobody came?

This was the question CanaDAM organizers faced as they planned the inaugural biennial conference for May 28–31, 2007 at the Banff Conference Centre. Negotiating hotel room commitments was tricky given that no one was sure how many people would attend. A poll of virtually all discrete and algorithmic mathematicians across Canada suggested that a target audience of 100 attendees would be a reasonable goal. To be on the safe side with respect to financing, the budgeting threshold was set at 60 attendees; if fewer people showed up, the conference would lose money.

Suppose you hosted a conference and *everybody* came?

This was the question CanaDAM organizers faced as registrations for the conference started pouring in. The 120-seat room initially booked as the main hall was replaced with a 250-seat lecture hall; the number of parallel sessions was increased to five; additional hotels were found to provide extra accommodation. In the end, around 230 people attended CanaDAM 2007 with representation from 36 Canadian universities, all 10 provinces and every continent except Antarctica. It was especially gratifying that about 80 graduate students and postdocs attended the conference.

There were 8 plenary lectures, 51 invited minisymposia talks, 62 contributed minisymposia talks and 71 contributed talks. To ensure critical mass in the areas covered by the plenary speakers, each plenary lecture was the focus of at least one invited minisymposium.

The Program Committee of CanaDAM 2007 was chaired by Bojan Mohar (SFU) and the Local Arrangements Committee by Ryan Hayward of (Alberta).

One of the primary goals of the conference was to encourage the participation of Canadian graduate students and PDFs. The three Canadian Mathematics Institutes (Fields, CRM and PIMS) provided $25,000 to support the attendance of graduate students and PDFs. In order to receive financial support graduate students were encouraged to contribute talks; there was also a problem session (followed by a reception) devoted to the presentation of research problems appropriate for graduate students. These problems will appear in *Discrete Mathematics*.

The strong Canadian and international attendance of CanaDAM 2007 suggests that the CanaDAM conference series is already established as one of the main international conferences on discrete and algorithmic mathematics.

A great deal of the credit for the success of CanaDAM goes to the outstanding international list of plenary speakers, drawn from both academia and industry. (iCORE and MITACS each provided $10,000 in support of the plenary speakers and graduate students.)

Derek Corneil (Toronto)

OPERATOR ALGEBRAS PROGRAM

continued from page 2

with infinitely many degrees of freedom has infinitely many inequivalent irreducible representations. This had been, perhaps, recognized implicitly ten years earlier by Gelfand and Naimark in their highly non-trivial axiomatization of C*-algebras as abstract *-algebras (independently of any representation).

Although von Neumann algebras had a much simpler representation theory, their internal structure was just as complicated as that of C*-algebras. This was a direct reflection of the subtlety of C*-algebra representation theory. Typically, as soon as the C*-algebra is not the algebra of compact operators, not only are different representations unitarily inequivalent, but also, they generate non-isomorphic von Neumann algebras.

Two of the unifying themes of operator algebras, since the beginning of the subject, have been the questions of classification up to isomorphism—respectively, for von Neumann algebras and for C*-algebras. In the presence of natural countability and amenability assumptions, the classification of von Neumann algebras has now been solved, and the classification of C*-algebras is perhaps approaching resolution.

The von Neumann algebra classification question was considered by Murray and von Neumann already in 1935, but only solved fifty years later, by work of Connes and others, which built on major advances in the 1960s—notably, work of Tomita and Takesaki (and others) which showed that a von Neumann algebra may be thought of as evolving in a natural way in time.

The C*-algebra classification question came up in the commutative case in the work of Gelfand and Naimark in 1943, but the first step after that was the case of infinite tensor products of matrix algebras considered by Glimm in 1959. An extension of Glimm's results to the more general class of approximately finite dimensional C*-algebras (AF algebras), in three stages, by Bratteli, me, and Effros, Handelman and Shen, was completed only in 1979.

My work, for almost forty years, has mainly been related to this C*-algebra question. This has in particular involved the development of operator algebra K-theory. K-theory was present, to be sure, in an embryonic way in the work of Murray and von Neumann. It was the basis of their so-called type classification. K-theory was developed into a powerful tool in geometry and topology by Grothendieck and Atiyah and Hirzebruch—incorporating the Bott periodicity theorem! This theory was recognized as important in operator algebras, partly through my work on AF algebras.

This expansion of operator algebra theory led to the non-commutative geometry of Alain Connes, which is related in a deep way to many branches of both mathematics and physics. In particular, the invariant used for the (amenable) von Neumann algebra classification, the so-called Connes-Takesaki flow of weights, may be thought of as K-theoretical in nature. Also the Jones index, basic to the classification of (amenable) subalgebras of von Neumann algebras (subfactors), and to the discovery of the Jones knot polynomial, is a K-theoretical quantity.

Non-commutative geometry has led to powerful generalizations of the Atiyah-Singer index theorem, to a new formulation of the standard model of elementary particle theory, and to a better understanding of the renormalization problem for Feynman diagrams. Much of string theory and M-theory is related to the ideas of Connes and Jones.

Three other areas of operator algebra theory which have appeared more or less serendipitously over the last twenty years are free probability, operator spaces, and quantum groups.

Free probability theory, introduced by Dan Voiculescu, is a remarkable synthesis of random matrix theory with the theory of free groups. It is based on Voiculescu's observation that, if one looks at the calculation by Kesten of the spectral distribution of the self-adjoint part of the sum of the unitary operators corresponding to the generators of a free group, then the limit of this as the number of generators increases exists, and is equal to the distribution obtained by Wigner as the limit of the eigenvalue distribution for a large random self-adjoint matrix, now called the Wigner semi-circle law. The very fertile theory that this led to has become a powerful tool in the theory of operator algebras, as is shown by work of Voiculescu and others on the von Neumann algebra of a free group, and by work of Haagerup on traces of an exact C*-algebra and on invariant subspaces of elements of a finite von Neumann algebra.

Operator space theory, first developed by Effros and Ruan, concerns closed subspaces of operators on a Hilbert space, not necessarily closed under multiplication or even taking adjoints, but considered, like C*-algebras, with the natural norm on matrices over the space. This structure has very interesting properties. As discovered by Ruan it can be axiomatized in a simple way, and as a consequence, can be shown to be preserved on passing to the quotient by a closed subspace. (Much as the quotient of a C*-algebra by a closed two-sided ideal can be shown to be a C*-algebra, but only after the abstract axiomatization.) One proof of the importance of operator spaces is that, while amenability of a locally compact group is not in general equivalent to Banach algebra amenability of its L^1-algebra, amenability of the group can be recovered (as was shown by Ruan) from an operator space notion of amenability for the L^1-algebra.

Quantum groups, developed in the compact case independently in an algebraic setting by Drinfeld and Jimbo, and in the setting of operator algebras by Woronowicz, have had a fairly broad impact in mathematics (and in particular have been useful for constructing subfactors). While discrete quantum groups have also been studied for some time—and shown to be dual to compact groups—locally compact quantum groups were only discovered recently (by Kustermans and Vaes). In contrast to the compact or discrete case, a locally compact quantum group can only be defined as an operator algebra. This theory is self-dual—the dual of a locally compact quantum group (in particular, of a locally compact group) is another such object (incidentally, this is also true for an operator space), and the double dual is the object itself.

George A. Elliott (Chairman-Organizing Committee, Operator Algebras Thematic Program)

WORKSHOP ON PERSPECTIVES FOR MATHEMATICAL NEUROSCIENCE

continued from page 11

experimentalists for the work involved in performing experiments and theoreticians for modeling and analyses. It was noted that significant time and effort are required to develop cross-disciplinary relationships. As a result, having good mentorship should be of top priority for someone entering the field. It was also felt that injecting more flexibility into graduate programs as well as having "translation" type shared courses between theory and experiment would be useful.

Aside from organizers and speakers, there were over sixty-five participants that included undergraduates (6), graduate students (25), postdocs (10), faculty (15), program officers from the National Science Foundation and National Institutes of Health, and several "others" (15). We were delighted with the large number of undergraduate and graduate students, and we were personally thanked by several participants who found the discussions to be invaluable.

Sue Ann Campbell (Waterloo), Mary Pugh (Toronto), Frances Skinner (Toronto and UHN) and Richard Zemel (Toronto)

CANADIAN OPERATOR SYMPOSIUM

continued from page 9

Scientific highlights of the meeting included a provocative talk by Vern Paulsen (Houston), in which he conjectured that the long-standing Kadison-Singer problem has a negative answer. The conjecture led to a friendly bet with Heydar Radjavi (Waterloo) over libations later in the evening. In addition to covering traditional areas of operator research, an effort was made at this year's COSy to facilitate interaction between the operator and quantum information communities. Quantum information based talks included plenary addresses by Daniel Gottesman (Perimeter Institute) on quantum error correction, Fotini Markopoulou (Perimeter Institute) on operator algebras in quantum gravity, and Mary Beth Ruskai (Tufts) on commutant lifting and quantum information theory. The meshing of operator algebra theory with various aspects of dynamical systems was a basic theme in several talks, including the plenary addresses of Kenneth Davidson (Waterloo) on higher-rank graph algebras, Elias Katsoulis (East Carolina) on operator algebras and multivariable dynamics, and Ian Putnam (Victoria) on C*-algebras from hyperbolic dynamical systems. Further plenary addresses included Man-Duen Choi (Toronto) on nonlinear inequalities in matrix analysis, Elliott on the Cuntz semigroup and K-theory for C*-algebras, Alexandru Nica (Waterloo) on free additive convolution, and Marius Junge (UIUC) on noncommutative Riesz transforms.

With over 65 participants and 32 talks, the 2007 version of COSy was a very active scientific meeting. There was also plenty of time to interact socially, and numerous collaborations were initiated or pushed forward.

In fact, this year's COSy was informally regarded as the beginning of the fall thematic program at Fields, and was an affiliated event of the *Taming the Quantum World* series of conferences and workshops held through June at the Institute for Quantum Computing and Perimeter Institute.

David Kribs (Guelph)

MICS TO BE LAUNCHED IN JANUARY

continued from page 4

Michael and Laura Gass), that MICS has become a reality.

To facilitate rapid publication and support public knowledge dissemination, MICS is entirely electronic and the Open Journal System of the Public Knowledge Project is used to handle manuscript submission and online publication.

Huaxiong Huang, Managing Editor of MICS

THANKS TO OUR SPONSORS

MAJOR SPONSORS

Government of Ontario–Ministry of Training, Colleges, and Universities; Government of Canada–Natural Sciences and Engineering Research Council (NSERC)

CORPORATE SPONSORS

Algorithmics, General Motors, QWeMA, R2 Financial Technologies Inc., Sigma Analysis and Management

PRINCIPAL SPONSORING UNIVERSITIES

Carleton University, McMaster University, University of Ottawa, University of Toronto, University of Waterloo, University of Western Ontario, York University

AFFILIATED UNIVERSITIES

Nipissing University, University of Guelph, University of Houston, University of Manitoba, University of Maryland, University of Ontario Institute of Technology, University of Saskatchewan, Queen's University, University of Windsor, Wilfrid Laurier University

The Fields Institute receives and welcomes donations and sponsorships from individuals, corporations or foundations, and is a registered charity.

The Fields Institute is grateful to all its sponsors for their support.

The Fields Institute for Research in Mathematical Sciences publishes FIELDSNOTES three times a year (September, January, and May).

Director: Barbara Lee Keyfitz
Deputy Director: Juris Steprāns
Managing Editor: Laura Gass
Distribution Co-ordinator: Tanya Nebesna
Scientific Editor: Carl Riehm

continued from page 20

faculty to "publish, publish", and in excellent journals, is not (one hopes) designed to set people up for failure but to inspire them to improve their work by setting high standards. MICS has been fortunate to attract, in John Ockendon, Alistair Fitt and Huaxiong Huang, three of the world's experts in industrial mathematics. They in turn have assembled a large editorial board who will not only produce an excellent journal but will be pioneers in designing what should be the standards of the future for the academic recognition of industry collaboration.

The social sciences are not the first area one thinks of when the words "applied mathematics" are mentioned. But as the daughter of a statistician/demographer I have been aware of this field all my life, and so was thrilled at the possibility of helping Fields to reach out in this direction. A generous donation from my parents and encouragement from a number of people at Fields, especially Tom Salisbury, has turned this dream into a reality. Elsewhere in this newsletter, you will find an article on the first public lecture on "Mathematics and Society", with speaker Joel Cohen, on *How Many People Can the Earth Support. And How Do You Know That?* (A recording of the talk can be found on the Fields web page.) Later this fall, we will run the second: on October 30, Nevanlinna prize winner Jon Kleinberg will speak on *The Geography of Social Networks*. It's our intention to have one public lecture a year on the theme of mathematics and the social sciences. As the first two titles suggest, this is an area with an enormous variety of interesting applications of mathematics. My parents, finding themselves at age 94 too elderly to travel, enjoyed the recording of Cohen's lecture from the comfort of their apartment in Massachusetts. My father's reaction? He liked the talk and thought the production values were good, but recommended that Tom and I, who did the introduction, invest in a teleprompter for Fields so that we would not appear to be looking down at our notes. He's always been a great believer in technology for a good social cause.

We'll take it up with the Board.

Statistical Science: Present Position and Future Prospects

This conference commemorating the 50th Anniversary of the University of Waterloo and the 40th Anniversary of the Department of Statistics and Actuarial Science at the University, and celebrating the achievements of the department's graduates and faculty members, took place from May 30–June 1, 2007. Plenary talks, providing overviews of selected topics, were given by 17 prominent graduates of the department. The conference was attended by approximately 120 researchers, from as far away as Africa, Europe, Great Britain and New Zealand.

The talks covered a very wide range of topics in statistical methods and theory and dealt with several fields of application. Many of the talks concerned work of high impact in areas such as environmental science, finance and insurance, genomics, medicine, and public health. Speakers also provided their thoughts on where various fields may be headed, and in the last session of the conference there was a discussion about the present position of statistical science, and what the future may hold. One certainty is that the discipline will continue to be stimulated by challenging problems arising in diverse fields.

The conference was organized by Jerry Lawless, Bovas Abraham, Richard Cook, David Matthews, Harry Panjer, and Mary Thompson (Waterloo).

Jerry Lawless (Waterloo)

NOTED

JEFFREY ROSENTHAL has been awarded the 2007 Committee of Presidents of Statistical Societies Presidents' Award (COPSS). This announcement was made at the Joint Statistical Meetings, in Salt Lake City. The Presidents' Award is the most prestigious honour bestowed by COPSS. It is awarded annually to a statistician under the age of 40 in recognition of outstanding contributions to the profession.

FRSC 2007: Fields would like to congratulate the following mathematical scientists elected as new members to the Academy of Sciences of the Royal Society of Canada: David C. Brydges, Walter Craig, and Lisa Jeffrey.

MIROSLAV LOVRIC, co-chair of the Fields Mathematics Education Forum, has been awarded a provincial LIFT (Leadership in Faculty Teaching) Award. Awards are presented to faculty who influence, motivate and inspire students as well as demonstrate leadership in teaching methods.

UMA GUPTA, Fields Institute's Financial Controller, was featured in the 06-07 Annual Report of the Certified General Accountants of Ontario (CGA), in a tribute to "CGAs who make a daily difference to communities across Ontario."

Call for Proposals, Nominations, and Applications

For detailed information on making proposals or nominations, please see the website: www.fields.utoronto.ca/proposals

General Scientific Activities*

Proposals for short scientific events in the mathematical sciences should be submitted by October 15 or March 15 of each year, with a lead time of at least one year recommended. Proposals will be considered at other times as funds permit. Activities supported include workshops, conferences, seminars, and summer schools. If you are considering a proposal, we recommend that you contact the Director, Barbara Keyfitz, or Deputy Director, Juris Steprāns (proposals@fields.utoronto.ca)

Thematic Programs *

Letters of intent and proposals for semester long programs at the Fields Institute are considered in the spring and fall each year, and should be submitted by March 15 or August 31. Organizers are advised that a lead time of several years is required, and are encouraged to submit a letter of intent prior to preparing a complete proposal. The Fields Institute has started a new series of two-month-long summer thematic programs focussing on interdisciplinary themes. Proposals for the summer of 2009 are now being considered. Organizers should consult the directorate about their projects in advance to help structure their proposal.

Postdoctoral Opportunities

Applications are invited for postdoctoral fellowship positions for the 2008-2009 academic year. The thematic program on **Arithmetic Geometry, Hyperbolic Geometry and Related Topics** will run in the fall of 2008, and the program on **o-Minimal Structures and Real Analytic Geometry** in winter/spring 2009. Qualified candidates who have recently completed a PhD in a related area of the mathematical sciences are encouraged to apply. The fellowships provide for a period of engagement in research and participation in the activities of the Institute. They may be offered in conjunction with partner universities, through which a further period of support may be possible. One recipient will be awarded the Institute's prestigious Jerrold E. Marsden Postdoctoral Fellowship. Applicants seeking postdoctoral fellowships funded by other agencies (such as NSERC or international fellowships) are encouraged to request the Fields Institute as their proposed location of tenure, and should apply to the address below for a letter of invitation. Additional support is available from NSF to support junior US visitors to this program. Applications are encouraged from all qualified candidates, particularly aboriginal peoples, persons with disabilities, members of visible minorities and women.

The deadline for postdoctoral applications for the 2008-2009 programs is December 7, 2007, although late applications may be considered.
Postdoctoral opportunities also exist at some of the Fields Institute's sponsoring universities.
Consult www.fields.utoronto.ca/proposals/#pdf for details.

CRM–Fields–PIMS Prize

Nominations are invited for this joint prize in recognition of exceptional achievement in the mathematical sciences. The candidate's research should have been conducted primarily in Canada or in affiliation with a Canadian university.

Please send nominations to: The Deputy Director, Fields Institute, 222 College Street, Toronto, Ontario, M5T 3J1 Canada

Nominations for the CRM-Fields-PIMS Prize should reach the Fields Institute by November 1, 2007.

Distinguished Lecture Series in Statistical Science (DLSS)

Nominations are being solicited for the eighth Fields Institute Distinguished Lecture Series in Statistical Science, to be given in spring 2008. The awardee will be an internationally prominent statistical scientist, who will give two lectures (one general, one specialized) at the Fields Institute.
Nominations for the DLSS should reach the Institute by October 1, 2007, although late applications may be considered.

***A note on diversity**. **In proposing any activity, applicants are requested to consider the mandate of the Institute to broaden and enlarge the community.** Applicants should explain how they plan to include women and members of visible minority groups in the proposed activity. As well, they should ensure that the proposed participant lists include scientists representing a range of career levels, types of institutions and geographical locations in Canada and abroad.

Fields Activities

Chalk it up to Mathematics

SEPTEMBER 2007 – JANUARY 2008 FIELDS

at Fields unless otherwise indicated

Detailed information: www.fields.utoronto.ca/programs

Thematic Programs

THEMATIC PROGRAM ON OPERATOR ALGEBRAS
JULY – DECEMBER, 2007

Organizers: George Elliott (chairman, Toronto), Dietmar Bisch (Vanderbilt), Joachim Cuntz (Münster), Kenneth Davidson (Waterloo), Thierry Giordano (Ottawa), Roland Speicher (Queen's)

SEPTEMBER 17 – 21, 2007
Workshop on Free Probability, Random Matrices, and Planar Algebras

OCTOBER 29 – NOVEMBER 2, 2007
Workshop on von Neumann Algebras

NOVEMBER 12 –16, 2007
Workshop on Structure of C*-Algebras

DECEMBER 11 – 15, 2007
Workshop on Operator Spaces and Quantum Groups

THEMATIC PROGRAM ON NEW TRENDS IN HARMONIC ANALYSIS (BEGINS IN JANUARY)

Organizers: Alex Iosevich (University of Missouri-Columbia), Izabella Laba (UBC), Michael Lacey (Georgia Institute of Technology), Eric Sawyer (McMaster University)

JANUARY 7 – 11, 2008
Workshop on Recent Advances in Operator Theory and Function Theory
(For details about later wokshops from this thematic program, visit our website)

This program has received support from the National Science Foundation. Post-doctoral students and junior researchers from US universities are encouraged to apply for funding.

General Scientific Activities

SEPTEMBER 22 – 24, 2007
Geometrization of Probability Workshop
University of Ottawa

SEPTEMBER 27 – 28, 2007
Distinguished Lecture Series in Statistical Science
Persi Diaconis (Stanford)

SEPTEMBER 28 – 30, 2007
1st Canadian Computer Algebra- and Dynamic Geometry Systems in Mathematics Education Conference
Nipissing University

OCTOBER 30, 2007
MATHEMATICS AND SOCIETY
The Nathan and Beatrice Keyfitz Lectures in Mathematics and the Social Sciences
Jon Kleinberg (Cornell)

NOVEMBER 5 – 7, 2007
Distinguished Lecture Series
Uffe Haagerup (Odense)

NOVEMBER 9 – 10, 2007
Conference in Honour of the 60th Birthday of Professor Andreas R. Blass

NOVEMBER 11, 2007
Royal Canadian Institute Lecture Series
Walter Whiteley (MIT and York)

NOVEMBER 22 – 23, 2007
Fields Workshop on Spread in Forests
University of Western Ontario

DECEMBER 14 – 16, 2007
Asympotic Group Theory and Cryptography Workshop
Carleton University

JANUARY 14 – 17, 2008
Conference on Mathematical Physics and Geometric Analysis

MESSAGE FROM THE DIRECTOR

ICIAM 07 and Applied Mathematics

LAST YEAR AT THIS TIME, I DELIVERED A ROSY report on the International Congress of Mathematicians. This September, it's the turn of applied mathematics. Zurich, Switzerland, and the Swiss Mathematical Society hosted the 6^{th} *International Congress on Industrial and Applied Mathematics*, July 16-20, 2007. This series of quadrennial meetings is run under the auspices of *ICIAM*, the *International Council on Industrial and Applied Mathematics*. It was a banner meeting for Canadian mathematicians. According to the official registration count, there were 91 Canadian attendees (out of about 3,100 participants), which is already impressive. In addition, of the thirty-one invited and special lectures, four were given by Canadians, including Pauline van den Driessche's Olga Taussky-Todd lecture (*Matrices in Action*) and Ivar Ekeland's public lecture, *The best of all possible worlds*. In fact, two of the three Canadian mathematics institute directors gave invited talks. (As for the third, it's a pleasure to point out that he gave an invited address at the ICM in Madrid last year.)

One reason for the great interest in ICIAM 07 is that Canada will be the host country for ICIAM 11, which will take place in Vancouver, July 18-22, 2011. The sponsoring institutions AIMS, MITACS and SIAM worked hard on their bid, which was accepted two years ago, and since then have been working even harder to organize a congress that will be up to the (very high) Swiss standards. ICIAM 11 will be co-directed by Ivar Ekeland and Jerrold Marsden; Arvind Gupta is the Scientific Director and planning is well underway. This is an event that will attract the interest of the entire mathematical sciences community.

If you find more variety than usual in this issue of Fields Notes, it may be because it is four pages longer than usual! The editors (Laura Gass and Carl Riehm) often have a difficult time selecting material to omit from the many excellent reports they receive on Fields activities. The four-month period of May to August of this year may have been no busier than our usual busy summer schedule, but it generated such a flow of reports that we have accommodated them by increasing our page count. I would particularly like to mention three activities that I worked on.

Derek Corneil's article on the *First Canadian Discrete and Algorithmic Mathematics Conference*, an event that took place in May, mentions the role of the three mathematics institutes in supplying funding for junior mathematicians. In addition to that, the conference provided an opportunity for the three institutes to cooperate with each other and with the organizers to put in place a high-quality nationwide event. We all like to think that because we are here, other people have good ideas.

A second initiative, a long time in the making, is described in Huaxiong Huang's article on MICS, the new Mathematics-in-Industry Case Studies electronic journal. This will be Fields's first new publication venture in several years. It has been under discussion by

Barbara Keyfitz

the Industrial Advisory Board for some time – a blueprint was on my desk when I arrived here three years ago – but it has taken a while for ideas to gel. As I noticed from my experience in working with the Fields-MITACS Industrial Problems Workshop participants a year ago, the academic applied mathematics community needs a place for archival publication of the results of "industrial encounters". An industry problem solved makes a good story, but where does it fit in the tenure dossier of an assistant professor? One of the important lessons industrial problems workshop participants learn is that the definition of success in industry is very different from the way success is measured in academia. In particular, the pressure on

continued on page 17

FIELDS INSTITUTE
Research in Mathematical Science
222 COLLEGE STREET, 2ND FLOOR
TORONTO, ONTARIO,
CANADA M5T 3J1
Tel 416 348.9710 Fax 416 348.9714
www.fields.utoronto.ca

FIELDS