THE FIELDS INSTITUTE
FOR RESEARCH IN MATHEMATICAL SCIENCES

NEWSletter

JUNE 2003

Inside ...

DIRECTOR'S MESSAGE

The SARS outbreak created widespread concern, and had a temporary impact on travel to Toronto. While the Fields Institute remained open for business, as did the rest of the city, attendance at some of our events was affected. One small event was moved by the organizers, but by and large, we carried on. In particular, the Automorphic L-functions workshop was able to continue in large part because a majority of participants were already in residence. We are apparently past the danger now, and by the time this appears, we expect to be back in full swing.

I thought I would spend a bit of time talking about the Fields Institute's role in the training of graduate students. We try to provide a variety of activities aimed at graduate students, and supervisors should be aware that these events are available to all students. In particular, there are two or three courses each semester associated with our thematic programs. Even if you cannot come yourself, you might consider sending a student. Program budgets include a certain amount allocated to provide a supplementary living or travel stipend for participating graduate students. As well, for students within commuting distance, we try to schedule every class

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LECTURES BY PETER SARNAK

Peter Sarnak

This year's Distinguished Lecture Series, entitled *Automorphic L-functions and Equidistribution*, was delivered by Peter Sarnak of the Courant Institute and Princeton University on April 9, 10, and 11.

The first lecture gave an overview tracing back the notion of equidistribution in number theory to Dirichlet's celebrated theorem about primes in arithmetic progressions. After speaking about various generalizations of Dirichlet's theorem such as the famous

Peter Sarnak *continued on page 7*

Automorphic Forms: Weekly Activities

The Thematic Program on Automorphic Forms at the Fields Institute in the spring of 2003 featured many activities that are described in detail elsewhere. But, in addition to these events, there were also regular weekly activities—three courses and a members' seminar—which ran on Tuesdays and Thursdays.

The courses were somewhat unusual, I believe, in that they were all concentrated on the same topic—recent cases of Langlands Functoriality. The Tuesday morning course, by Jim Cogdell (Oklahoma State), dealt with the theory of L-functions for GL(n) in terms of their integral representations. It covered classical modular forms, automorphic forms, L-functions for GL(n), converse theorems, and finally, combining the converse theorem with the Langlands-Shahidi method of understanding L-functions, new cases of functoriality from classical groups to GL(n).

The Tuesday afternoon course given by Henry Kim (Toronto) was concerned with developing the Langlands-Shahidi method of controlling the analytic properties of automorphic L-functions. Kim developed the theory of algebraic groups, Eisenstein series, the Langlands-Shahidi method, and then combined this method with the converse theorem for GL(n) to derive the new cases of functoriality, particularly the symmetric cube and fourth power functorialities for GL(2).

The third course, given by Ram Murty (Queen's), took place on Thursday mornings. Less directed than the other courses, it was more of a selected-topics course that dealt with the many applications in analytic number theory of these new cases of functoriality, particularly the symmetric power functorialities. As a result, the three courses were highly co-ordinated and intertwined, and provided a particularly directed sense of identity for the Thematic Program.

As is often the case, the courses had a very large turnout for the first couple of weeks, but then settled down to a steady state of twenty to twenty-five tenacious participants. It was a broad audience that included both the Fields members in the Thematic Program as well as participants from the University of Toronto and elsewhere. Participants ran the spectrum—from John Friedlander (Toronto), who is both a Fields Institute Fellow and a winner of the CRM–Fields Prize, to Karen Yeats, an undergraduate participant in the Thematic Program from Waterloo, and everyone in between. In addition, Philippe Michel and Guillame Ricotta from Montpellier, who came to the Fields as members in April, had followed the courses on the web so that they were current upon their arrival. Perhaps there were other virtual attendees for the courses as well.

The Members' Seminars, held Thursday afternoons, gave members of the Thematic Program a chance to speak on their own work. Seminars were regularly attended by most members. Again, the range of speakers and topics was quite broad, ranging from Joseph Bernstein, a senior participant from Tel-Aviv, to Kimball Martin, one of the graduate student participants from Cal Tech. I believe that every participant who desired to speak was given the opportunity to do so (as well as some who possibly had to be convinced).

March was a particularly active month. It coincided with the break between terms in Europe, and many of the European participants who came for the March Workshop on Shimura Varieties (March 4–8) stayed for most of the month. This led to two special Monday lectures: by Gerard Laumon (CNRS and Paris-Sud) and by Michael Rapoport (Köln). In addition, Steve Kudla's Coxeter Lecture Series took place in March. These events made April look calm, even taking into account Peter Sarnak's Distinguished Lecture Series.

Besides the activities at the Fields Institute, there were two activities at the University of Toronto which many of the participants in the thematic program attended. Jim Arthur was giving a course on the Trace Formula every Monday, Wednesday, and Friday morning. Many of the participants, particularly the postdoctoral members, attended Arthur's lectures regularly. In addition, on Wednesday afternoons U of T's regular Number Theory/Representation Theory Seminar was held. Many of the participants in the thematic program were regular attendees of this seminar, and several had the opportunity to speak there as well.

The thematic program is now winding down. The regular courses and seminars finished in the last week of April (actually on May 1), just in time for the final Workshop on Automorphic L-functions. Participation in this workshop is down owing to justifiable concern about SARS, but those of us who are here and those still coming from elsewhere will put on a spirited finish to this program.

Jim Cogdell (Oklahoma State and Fields)

Editor's Note: Overheard in the Fields Institute corridors à propos the three courses on automorphic forms: "H. Kim's course was strong vodka; J. Cogdell's course was bubbly champagne; and R. Murty's course was sweet wine which even children can drink."

THE FIELDS INSTITUTE
FOR RESEARCH IN MATHEMATICAL SCIENCES

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

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Coxeter Lecture Series: Stephen S. Kudla

Arithmetic Theta Series

The spring 2003 Coxeter lectures, a part of the thematic program on automorphic forms, were given by Stephen S. Kudla (Maryland) on March 9, 10, and 11. Kudla's main research interests lie within number theory, in particular in the area of automorphic forms and theta series. One constant theme of his work throughout his career has been his interest in the relationship of automorphic forms to differential and arithmetic algebraic geometry.

Kudla received his PhD in 1975 from the State University of New York, Stony Brook. He was a member of the Institute for Advanced Studies in Princeton in 1975–76 and since then has been at the University of Maryland. He was the recipient of a Sloan Fellowship in 1981 and received the Max Planck Research Prize from the Deutsche Forschungsgemeinschaft in 2000. He has given invited lectures on his work at the Séminaire Bourbaki and at the ICM 2002 in Beijing.

In the three Coxeter lectures, Kudla presented an overview of the recent progress in his extensive and ongoing program in collaboration with M. Rapoport and T. Yang to realize generating series arising in arithmetic algebraic geometry as modular forms, in particular as derivatives of certain Eisenstein series.

In the first lecture, he began by putting his research program into context. It has been known for a long time that the most classical theta series—the generating series of representation numbers of integers by a positive definite integral quadratic form—give rise to modular forms. To indefinite quadratic spaces one can associate locally symmetric spaces, and starting in the 1970s, it was realized that certain geometric theta series give rise to holomorphic Siegel modular forms as well. This was carried out in greatest generality by Kudla and J. Millson. In this setting, the generating series involve sub-symmetric spaces and take values in the de Rham cohomology of the locally symmetric space. Kudla explained this theory in detail for certain complex surfaces.

Earlier results by Kudla and his collaborators indicate an analogous and more general theory in arithmetic algebraic geometry. As further evidence in this direction, he presented the striking result that generating functions for curves on the arithmetic surface attached to a Shimura curve over the rational numbers are again modular forms. These generating series, accordingly named arithmetic theta series, now take values in the arithmetic Chow group of the Shimura curve. Furthermore, he introduced in this context an arithmetic theta lift from the space of modular forms to the arithmetic Chow group and outlined the way in which one obtains variants of the celebrated results of Gross–Zagier and Gross–Kohnen–Zagier.

The second and third lectures gave overviews of the techniques involved in proving such results.

Jens Funke (Fields Institute)

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on one day per week in order to accommodate commuters. Again, some travel support might be available. So think ahead and try to arrange research support during a semester when a senior grad student could take advantage of our offerings.

Also available for the benefit of graduate students are summer schools. Two are being run in June 2003, as you are reading this. At Fields, the Clay Institute has very generously funded a month-long school on Automorphic Forms, led by Jim Arthur and Robert Kottwicz, with about one hundred students, postdocs, and junior faculty participating. There are three weeks of introductory courses plus a week of high-level lectures. In Ottawa, a three-week school on Logic and Foundations of Computation is currently running with about thirty-five students. And in July, at Waterloo, a week-long summer school on Mathematics in Medicine will be followed by a workshop at Fields. We will continue to hold such events in the future.

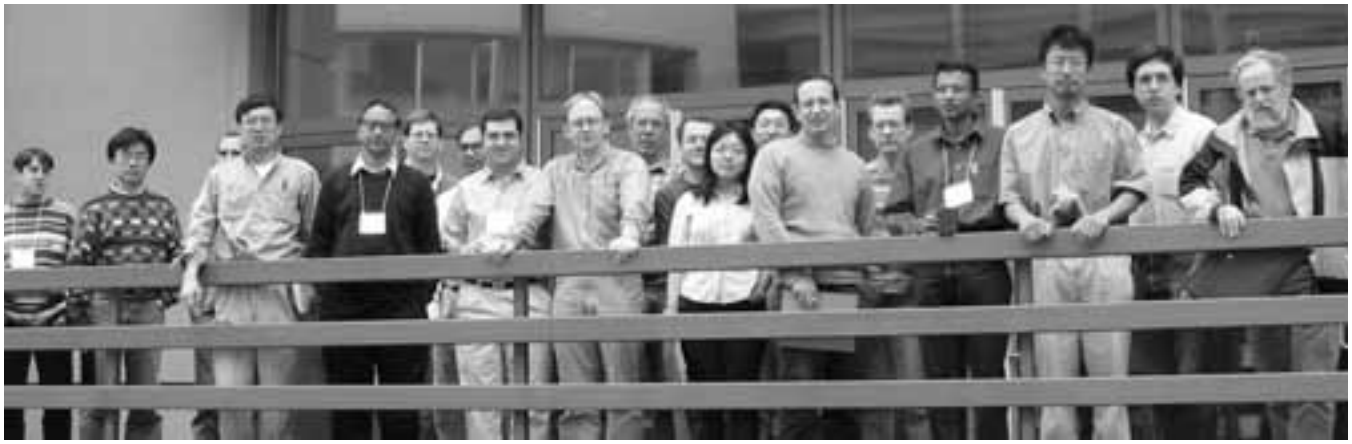
Of course, students with sufficient background can also profit from our regular activities such as workshops and feature lectures. Funding is limited for students at such events, but their participation is always welcome. So I urge you all to look out for opportunities at the Fields Institute for your students.

We have had three major lecture series during the spring semester. Two in the automorphic forms program—the Coxeter Lecture Series given by Stephen Kudla and the Distinguished Lecture Series given by Peter Sarnak—are described in this newsletter. There is also the fairly new Distinguished Lectures Series in Statistical Sciences, given this year by Donald Dawson, a former Director of Fields and a renowned probabalist. A report on the Dawson lectures will appear in the fall 2003 *Newsletter*.

June 12 is the date of our 2003 annual general meeting, which will include scientific activities open to all interested parties. There will be two keynote lectures, one by Juris Steprans of York University, one of the organizers of last fall's program on Set Theory and Analysis, and the other by Raymond Laflamme, a Canada Research Chair in physics at the University of Waterloo and director of the new Institute for Quantum Computing. In the evening, there will be a banquet with after-dinner speaker Moshe Milevsky, of the York University Schulich School of Business and Director of the Individual Finance and Insurance Decision Centre. He is the author of the popular personal finance book, *Money Logic*, and writes a regular column on personal finance in the *National Post Business Magazine*. We will also announce the names of seven new Fields Institute Fellows, an addition to the thirty-three who were inducted at the inauguration of the award at our tenth anniversary meeting in 2002. I hope to see many of you at the AGM.

Kenneth R. Davidson (Fields Institute)

Workshop on Automorphic L-Functions



Automorphic L-Functions Participants

The workshop on automorphic L-functions was held at the Fields Insitute, May 5–9, 2003. With more than forty participants and fifteen invited speakers, it was very stimulating and enjoyable. A leisurely schedule of three lectures each day allowed for opportunities for informal discussions and the free exchange of ideas among participants. The speakers were: J. Cogdell (Oklahoma State), W. Kuo (Queen's and Fields Institute), P. Michel (Montpellier), K. Murty (Toronto), S. Wang (Yale), A. Cojocaru (Fields), J. Friedlander (Toronto), Y. Petridis (CUNY), A. Raghuram (Purdue), J. Arthur (Toronto), J.-J. Lee (Queen's), W. Casselman (UBC), C. David (Concordia), A. Booker (Princeton) and H. Helfgott (Princeton). Some of the topics covered in the lectures included several aspects of functoriality, Selberg's conjectures, summatory functions, convolution problems, Artin L-functions and applications, and distribution of modular symbols and elliptic curves.

A conference dinner on the evening of May 8 (and the weather that day was favourable) provided an enjoyable diversion from the regimen of lectures.

Ram Murty (Queen's)

Workshop on Shimura Varieties and Related Topics

The subject of Shimura varieties has enjoyed several interesting developments in recent years. Progress has been made on aspects related to the local and global Langlands conjectures, to the theory of integral p-adic models and the fine structure of their reductions modulo p, and to higher-dimensional analogues of the Gross–Zagier formula. In addition, there have been advances in closely related fields: in the Arthur–Selberg trace formula and related harmonic analysis questions such as the "fundamental lemma" conjectured by Langlands–Shelstad, and in the study of related spaces such as affine Deligne–Lusztig varieties, and p-adic period domains.

The March 4–8, 2003, workshop brought together the leading experts on these exciting new developments. J. Arthur (Toronto) talked about the formulation of the global Langlands conjecture, and G. Laumon (Paris) on recent progress on the geometric case of the fundamental lemma. There were also talks by M. Rapoport (Köln) on conjectured properties of affine Deligne–Lusztig varieties, by D. Blasius (UCLA) and T. Ito (Tokyo) on the weight monodromy conjecture for Shimura varieties, by E. Mantovan (Berkeley) on the relation between the cohomology of Shimura varieties and that of p-adic period domains, by T. Yang (Wisconsin—Madison) on a variant of the Gross–Zagier formula, by C.-L. Chai (Penn) and H. Hida (UCLA) on the Hecke orbit structure of the reduction modulo p of Shimura varieties. The stellar list of speakers included additional researchers from Canada, France, Germany, Israel, Taiwan, and the United States. The result was a lively and successful workshop covering the broad range of intended topics and more.

This was the second workshop at the Fields Institute on the topic of Shimura varieties. The first was held in November 2001 and highlighted the connections between Shimura varieties and the geometric Langlands program. The Fields Institute once again provided an excellent venue for the event, continuing its great tradition of fostering scientific research and development.

Tom Haines (Maryland)

Applied Mathematics Colloquium

The invited speakers presented some of the very best current work in partial differential equations, mathematical physics, and medical imaging. Their talks attracted a wide audience of graduate students, postdoctoral fellows, and

Applied *continued on next page*

colleagues from within and without mathematics departments in the Greater Toronto Area.

The speakers were Charles Fefferman (Princeton) on *Formation of Sharp Fronts in 2D Incompressible Fluids*, Sergiu Klainerman (Princeton) on *The Problem of Evolution in General Relativity*, Charles Epstein (Pennsylvania) on *Pulse Synthesis in NMR*, Joel Smoller (Michigan) on *Cosmology, Black Holes, and Shock Waves beyond the Hubble Distance*, Rafe Mazzeo (Stanford) on *Poincaré-Einstein Metrics on the Large and Small Scale*, Russel Caflisch (UCLA) on *Dynamics of a Step Edge in Thin Film Growth*, and Peter Constantin (Chicago) on *Remarks on Rotating Fluids*.

For abstracts and audio recordings of the talks please visit: http://www.fields.utoronto.ca/audio/#applied_math

The series was popular not only with the audience but with the speakers themselves, and invaluable for the mathematical discussions it generated inside and outside the seminar room. Charles Fefferman extended his visit to a full week and agreed to also give a talk on his work in financial mathematics.

Organizers for the 2002–2003 Applied Math Colloquium were Jim Colliander (Toronto), Nicholas Kevlahan (McMaster), Adrian Nachman (Toronto), and Mary Pugh (Toronto). We worked hard to maintain the high standards set by Walter Craig and Catherine Sulem in previous years. The series was supported by the Fields Institute and by NSERC through the individual grants of the organizers.

Adrian Nachman and Mary Pugh

Mathematics outside Mathematics

This year saw the birth of a new colloquium series, Mathematics outside Mathematics, already affectionately known as "MOM." The aim was to create a forum for presenting exciting current scientific and engineering work that involves substantial mathematics but takes place outside mathematics departments. The organizers worked energetically to attract graduate students and postdoctoral fellows and to expose them to interesting and challenging problems requiring serious mathematics that they would not otherwise encounter. In this spirit, the speakers chosen were top researchers known also for their ability to communicate compellingly across disciplinary lines in both mathematics and their own fields.

The series was organized by Jim Colliander (Toronto), David Earn (McMaster), Adrian Nachman (Toronto), and Mary Pugh (Toronto).

The first colloquium, *Randomly Coloured Self-avoiding Walks: A Model of Random Copolymers*, was given by Stuart Whittington (Chemistry, Toronto). Imagine the complicated configurational structure of a chain of identical molecules, like beads on a string. Now consider chains made by randomly selecting one of two molecule types: one hydrophilic and the other hydrophobic. If one were to put such a chain into a beaker of water and oil, where would you expect to find the molecules? Mostly in the oil? In the water? In the oil/water interface? Whittington's methods are from statistical mechanics, computational physics, and probability.

In the second colloquium, John Sipe (Physics, Toronto) spoke on *Effective Field Theories for Nonlinear Optics in Artificially Structured Materials*. The propagation of a pulse down an optical fiber is often studied via an equation such as the nonlinear Schroedinger equation. Such "effective field equation" approaches have been proven tremendously fruitful. The derivation of these equations, however, has been largely for media which are close to uniform or to one-dimensional periodic media. Advances on artificially structured materials require a systematic method for deriving and studying the effective field equations for a wider class of media. Sipe's work in this area uses the methods of nonlinear PDE and perturbation theory.

Ray Kapral (Chemistry, Toronto), gave the third colloquium, *Twisting Filaments in Oscillatory Media*. Scroll waves are frequently observed in three-dimensional oscillatory and excitatory media. While beautiful to watch, they are not always friendly—scroll waves are suspected to be responsible for heart flutter and fibrillation. In this situation, the cardiologist seeks the fastest, most effective, and least damaging way to destroy scroll waves and return the heart its normal function. Understanding the source, stability, and control of scroll waves in various geometries is one of the goals of Kapral's work. His methods include nonlinear PDE, dynamical systems, and scientific computation.

In the fourth colloquium, Eugene Fiume (Computer Science, Toronto) spoke on *Signal Theoretic Characterisation of Three-dimensional Polygonal Geometry*. Wavelets and Fourier transform techniques have revolutionized signal theory, data compression, and data analysis. Fiume and his collaborators are using Fourier transform ideas to approximate and classify nontrivial solid objects in three-space. This is not easy. What would you choose as the "natural basis functions" to approximate a dog that is walking down the street? And how could your representation help you to distinguish quickly between a poodle, a cat, and a squirrel? Fiume's methods include graph theory and harmonic analysis.

Naomi Leonard (Princeton) was to have spoken in the final colloquium on *Schooling by Design: Co-ordinated Multi-Vehicle Dynamics*. Her talk fell victim to the SARS scare—Princeton issued a travel advisory even before the WHO did. Leonard's talk has been rescheduled for the fall 2003 semester, allowing her to present new results from this summer's experiments in California's Monterey Bay.

For abstracts and audio recordings of the talks please visit: http://www.fields.utoronto.ca/audio/#MOM

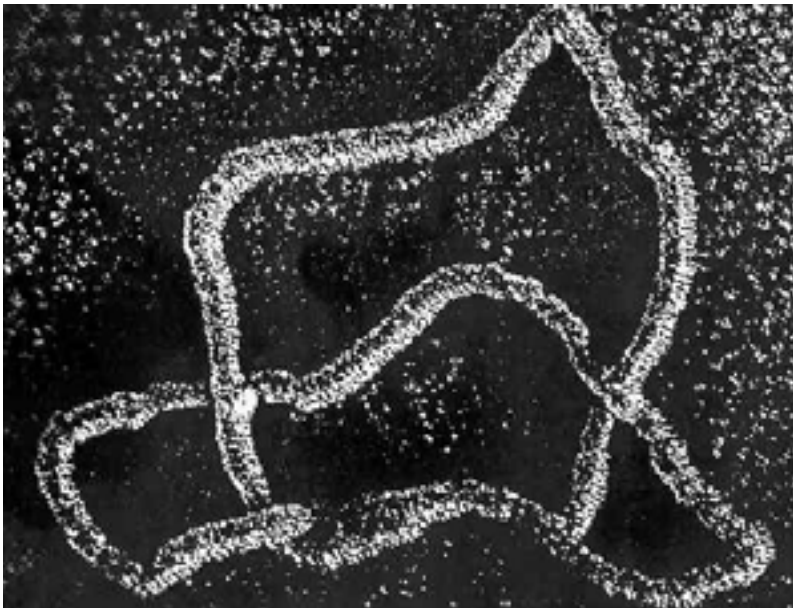
There were between thirty and forty people in the audience for the talks, and the post-talk tea discussions were always lively. The enthusiastic response from the audience was gratifying, and showed a definite interest in the mathematics community in the Toronto area for continuing the series. Future plans include inviting speakers from a wider geographical area and fostering collaborations across traditional boundaries in science and engineering.

Adrian Nachman and Mary Pugh

Random Knotting

A public lecture by Stuart Whittington (Toronto), sponsored by the Royal Canadian and Fields Institutes, was held at the University of Toronto, Sunday January 26, 2003.

The Royal Canadian Institute was founded in 1849 to promote the advancement of science. For many years, one of its principal activities has been running a series of Sunday afternoon public lectures on science in the fall and winter semesters at the University of Toronto. The Fields Institute has entered into a collaboration to make talks on mathematics a regular part of these lectures. The first of these was the talk by Whittington, an applied mathematician in the University of Toronto chemistry department.



Pair of Linked Circles of DNA

The theme of the lecture on *Random Knotting* was that long flexible objects—for example, string, garden hoses, and long molecules such as DNA—tend to get knotted and entangled. You can observe this in everyday activities. Biochemists also see this in molecules which have been fattened up with a protein batter and filmed under an electron microscope. Because they have both practical and decorative purposes, knots have fascinated people for centuries—mathematicians have studied them for a hundred years. A serious question is to decide whether two knots are the "same," i.e., by twisting and rearranging one knot without cutting it, can it be deformed into the other? And how can you tell if a string is actually knotted at all? The latter question is often easier because a knot in one part of the string means that the whole string is non-trivially knotted. One way to catalogue knots is to enumerate them by considering a representation with the minimal number of crossings when laid out on a flat surface. Of course, determining this number can itself be a challenge.

Whittington considered a model for building knots at random by connecting nodes in a cubic lattice. A fairly short segment of string along this lattice can be knotted. Among all such possible segments built at random, a positive percentage will be knotted—the longer the string, the greater the likelihood that a random loop will be knotted. Indeed, very long strings are extremely likely to have knots in them. In particular, this occurs in nature with strands of DNA, creating a problem for mitosis. In order to replicate itself, the DNA strand has to decouple from its copy—but that will not occur if it is knotted. Nature deals with this through several enzymes, one of which looks for places where the DNA strand crosses itself. The enzyme cuts one strand and reattaches it on the other side, changing the nature of the knot. Random effects will eventually untie the knot, allowing the copy to float free of the original!

Twists and writhes are other properties of knots. A strand of string or hose can be twisted many times. If the ends are held but moved closer together, the string will change shape with a section of twisted string pushing out from the main strand. This is called a "writhe." A quantitative measurement of twist and writhe can be made, and an old result known as White's Theorem says that the sum of the twist and writhe of a knot is constant. This again occurs in nature. Certain processes tend to push the twist along the molecule, causing it to bunch up. Enzymes come to the rescue again, moving the twist around the obstruction.

Today, there is an active collaboration between molecular biologists and applied mathematicians to pursue the study of knots in large molecules. For example, when biologists found a few simple knots in certain compounds, mathematicians predicted that other, more complicated knots should also occur, though less frequently. Biologists were then able to go back and find the predicted knots.

Kenneth R. Davidson (Fields)

Recently Honoured

Nancy Reid (Department of Statistics, University of Toronto) was elected Fellow of the American Association for the Advancement of Science.

Michel Delfour (Université de Montréal) has been awarded a Guggenheim Fellowship.

James Colliander (Mathematics), Kentaro Hori (Mathematics and Physics), Hae-Young Kee (Physics), and Daniel Lidar (Chemistry), all of the University of Toronto, have received Sloan Fellowships.

John Friedlander (Mathematics, University of Toronto) has received a Killam Fellowship; Oleg Bogoyavlenskij (Queen's University) and Victor Ivrii (University of Toronto) are in the second year of their Killam Fellowships.

Henry Kim (Mathematics, University of Toronto) has been awarded a 2003–2004 American Mathematical Society Centennial Fellowship.

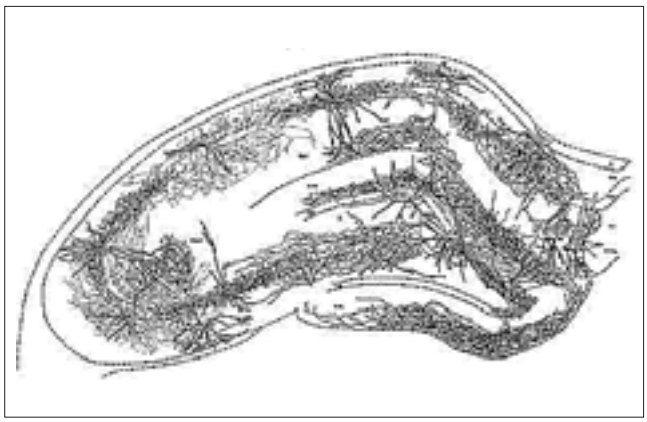
Computational Neuroscience in Upper Canada (CNUC)

Conversations over coffee gave rise to a small group in southern Ontario with an interest in methods and problems in computational neuroscience. Geography and shared interest alike led naturally to the acronym CNUC (Computational Neuroscience in Upper Canada). The primary motivation of the group is to exchange information between experimentalists and computational modellers in order to investigate how computational and mathematical approaches have been, or could be, used to address critical issues in neuroscience. An extended group, consisting of scientists from Toronto, York, McMaster, and Waterloo met in April, 2002 to organize the initial one-day "fire-side" chats, where three or four people presented their perspective on a theme. The talks are either in tutorial style, geared to general scientists, or more problem-oriented, where an issue is presented and the floor is then opened for discussion on how to deal with the issue (e.g., we have all this data from brain imaging; how do we characterize the dynamics?).

CNUC organizers are Richard Zemel (Computing Science, Toronto), Frances Skinner (Toronto Western Research and UT), and Randy McIntosh (Rotman Research Institute and UT). CNUC meetings are open to all, and anyone is welcome to suggest topics. Our hope is that this open forum will unify the computational neuroscience community, acting both to educate the researchers about the wealth of computational approaches and opportunities for application, and to facilitate new collaborations among scientists.

Since the initial organizational meeting, we have had four meetings at the Fields Institute on topics ranging from spikes and neural coding to neuroimaging and studying human behaviour.

At a meeting organized by Sue Ann Campbell (Applied Math, Waterloo), the theme was *Different Levels of Modelling*. The levels discussed included single neural cells, cell populations, coupled populations from different layers in the brain, and coupled artificial and biological networks. The applications of the models ranged from reproducing "optical illusions" produced by binocular rivalry to controlling behaviour in biological networks using artificial neural networks. There were four speakers: Berj Bardakjian (Toronto, IBBME), Sue Becker (Psychology, McMaster), Hon Kwan (Physiology, Toronto), and Hugh Wilson (York).



A Slice from the Hippocampus Showing Characteristic Interneuron Types and Regions

The next CNUC meeting was on *Spatial Representations in Motor Control and Navigation*. The speakers were Sue Becker, Jeremy Caplan (Rotman Research Institute), Hon Kwan, and Pieter Medendorp (York).

At the final CNUC meeting of the spring 2003 semester (May 8), organized by Frances Skinner, the topic was *The Hippocampus: Memories, Rhythms, Neurogenesis and More!*

Richard Zemel

Peter Sarnak *continued from page 1*

Chebotarev density theorem, Sarnak introduced the concept of an automorphic L-function. Good estimates for these L-functions on the "critical line" Re(s) = 1/2 lead to new equidistribution theorems. This often means one must penetrate what is usually called the standard convexity bound obtained by routine methods of analytic number theory. It is at this point that analytic techniques involving the Selberg trace formula or the cognate Kuznetsov trace formula intervene, leading one to the study of Maass forms and their eigenvalue distributions.

In his second lecture, Sarnak explained how ideas from ergodic theory and mathematical physics have inspired some recent work in the study of equidistribution of eigenfunctions of the non-Euclidean Laplacian.

In the third lecture, recent work of E. Lindenstrauss was described. This concerns the following conjecture: let M be a compact Riemannian manifold of negative curvature. Then, any sequence of eigenfunctions φ_i of the Laplacian (normalized to have L^2-norm 1) with eigenvalues λ_i tending to $-\infty$ has the property that

$$\int_M f(x)\,|\varphi_i(x)|^2\,d\mathrm{vol}(x) \to \mathrm{vol}(M)^{-1}\int_M f(x)\,d\mathrm{vol}(x).$$

Together with the work of Luo and Sarnak as well as recent work of Lindenstrauss, remarkable progress has been made towards this conjecture. There are notable arithmetic consequences in the case the manifolds are of the form H/Γ where H is the upper half plane and Γ is a congruence subgroup of $\mathbf{SL}_2(\mathbf{Z})$.

The three lectures were also recorded in their entirety and may be found at www.fields.utoronto.ca/audio. There is also a file relevant to Sarnak's work that can be downloaded from the website address www.math.princeton.edu/~sarnak/baltimore.pdf.

The lectures were a marvellous synthesis of diverse areas of mathematics, notably number theory, representation theory, ergodic theory, and mathematical physics. In addition, Sarnak's gregarious nature and wide view of mathematics made it a pleasure to hear him explain many things informally at the blackboard during tea time.

Ram Murty (Queen's)

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 are welcome any time, with a lead time of at least one year recommended. Activities supported include workshops, conferences, seminars, and summer schools. If you are considering a proposal, we recommend that you contact the Director (*davidson@fields.utoronto.ca*) or Deputy Directors (*bhart@fields.utoronto.ca* and, as of August 1, 2003, *tsalisbury@fields.utoronto.ca*).

THEMATIC PROGRAMS

Proposals for semester or year-long programs at the Fields Institute are considered in November and May of each year. Organizers are advised that several years lead time is required, and that they should contact the director early to discuss possibilities.

POSTDOCTORAL OPPORTUNITIES

Applications are invited for postdoctoral fellowship positions for the 2004–2005 academic year. The thematic program on **The Geometry of String Theory** will take place at the Institute from August 2004 to June 2005. 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 at least one year of engagement in research and participation in the activities of the Institute and may be offered in conjunction with partner universities. 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.

In addition to regular postdoctoral support, the **Jerrold E. Marsden Postdoctoral Fellowship** will be awarded. The stipend is $40,000 (Cdn), which provides for a twelve-month period at the Institute for research and participation in the activities of the core program. No teaching is required. A $2,000 (Cdn) research grant will also be available during the tenure of the award.

To be guaranteed consideration, postdoctoral applications should reach the Institute by January 6, 2004, although they may be considered after this date.

CRM-FIELDS PRIZE

The Centre de recherches mathématiques (CRM) and the Fields Institute for Research in Mathematical Sciences invite nominations for this joint prize in recognition of exceptional achievement in the mathematical sciences. The deadline is October 1. Previous recipients are H.S.M. Coxeter, George A. Elliott, James Arthur, Robert Moody, Stephen A. Cook, Israel Michael Sigal, William T. Tutte, John Friedlander, John McKay, and Edwin Perkins. Please see *www.fields.utoronto.ca/proposals/crm-fields_prize.html* for details.

Nominations for the CRM-Fields Prize should reach the Institute by October 1, 2004.

Please send applications, nominations, and proposals to:

The Director
The Fields Institute for Research in Mathematical Sciences
222 College Street, Toronto, Ontario, M5T 3J1 Canada

Activities July–December 2003

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

THEMATIC PROGRAMS

Partial Differential Equations, 2003–2004

Organizers: W. Craig, N. Ercolani, C. Sulem

August 2003 — **Mathematical Aspects of Fluid Dynamics,** Summer School
Organizers: W. Craig, N. Ercolani, C. Sulem

Aug. 25–30, 2003 — **The Calculus of Variations: Geometric Problems, Superconductivity, and Material Microstructures,** Workshop
Organizers: S. Alama, L. Bronsard, R. Choksi, R. Jerrard (Chair), R. McCann (Chair)

Graduate Courses

Sept. 2003–April 2004 — **Partial Differential Equations,** Instructor: W. Craig
Sept.–Dec. 2003 — **Wave Propagation,** Instructor: C. Sulem
Sept.–Dec. 2003 — **Optimal Transportation and Nonlinear Dynamics,** Instructor: R. McCann

TBA — **Mathematical Aspects of Fluid Dynamics,** Short Course
Instructors: W. Craig, C. Dafermos, C. Fefferman, B. Khesin

Oct. 1–4, 2003 — **Symposium on Inverse Problems**
Organizer: A. Nachman

October 20–22, 2003 — **Coxeter Lecture Series, Craig Evans** (Berkeley), Title TBA

Nov. 14–18, 2003 — **Patterns in Physics,** Workshop
Organizers: R. Almgren, N. Ercolani (Chair), D. Henderson, J. Lega, M. Pugh

GENERAL SCIENTIFIC ACTIVITIES

July 17–19, 2003
July 21–25, 2003 — **Infinite Dimensional Lie Theory and Its Applications,** Workshop and Conference
Organizers: B. Allison, S. Berman, Y. Billig, Y. Gao, E. Neher, A. Pianzola

July 21–26, 2003 — **Introduction to Mathematical Medicine,** Summer School Program at Waterloo

July 28–31, 2003 — **Applications of Mathematics in Medicine,** Workshop at Fields
Organizers: S. Sivaloganathan, J. Drake, M. Lewis, S. McKee, J. Murray
Medical Advisors: James M. Drake, Peter Sleight

July 30–Aug. 1, 2003 — **3rd Annual McMaster Optimization Conference (MOPTA 03),** at McMaster
Organizer: Tamás Terlaky

Sept. 1–30, 2003 — **Fields Institute Program on Applied Homotopy Theory,** at Western Ontario
Organizers: R. Jardine, D. Christensen

Sept. 3–5, 2003 — **Workshop on Statistical Genomics**

Sept. 4–5, 2003 — **2003 Stochastic Modelling Symposium,** at Crowne Plaza Hotel
Organizers: R. Berendsen, J. DeRoy, D.C. Gilliland, M. Roy, K.S. Tan

Sept. 19–20, 2003 — **Workshop for Canadian Queueing Theorists and Practitioners (CanQueue)**
Organizer: M. Mandelbaum

Sept. 26–27, 2003 — **Workshop on Adaptive Designs**
Organizers: N. Balakrishnan, N. Flournoy, S.G. Mohanty

October 21–23, 2003 — **Concentration Phenomenon, Transformation Groups, and Ramsey Theory,** University of Ottawa
Organizers: T. Giordano, D. Handelman, V. Pestov

Dec. 11–13, 2003 — **Workshop on Bifurcation Theory and Spatio-Temporal Pattern Formation**
Organizers: A.T. Lawniczak, V.G. LeBlanc, W. Nagata, N.S. Namachchivaya

CRM—Fields Prizes, 2003

John McKay (Concordia)
Edwin Perkins (UBC)

The Centre de recherches mathématiques and the Fields Institute are pleased to announce joint winners of the 2003 CRM–Fields Prize.

John McKay's work revolves around the properties of finite groups, their representations, and their symmetries. He has been at the origin of several of the most startling discoveries in mathematics of our time, and is world-renowned for launching two areas of mathematics through his observations and conjectures. One is now known as the McKay correspondence, and the other has the fanciful name of "monstrous moonshine," underlying the role of the largest sporadic simple group, the "monster." His wide knowledge of mathematics has allowed him to bring to the fore questions that have been deeply influential in the subsequent development of the discipline—for example, Richard Borcherds's work, which was recognized by a Fields medal at the 1998 International Congress of Mathematicians.

Among other achievements, McKay is a pioneer in the use of computers as a tool in algebra, both in the study of sporadic groups (he is the co-discoverer of two such groups) and in the explicit computation of Galois groups. He was also one of the principal actors in one of the feats of computational algebra of our time, the proof of the non-existence of a projective plane of order 10.

After obtaining his BA in mathematics at Manchester, McKay obtained his PhD in computer science at Edinburgh. He held appointments at the Atlas Laboratory in England, at Caltech, and at McGill University before moving to Concordia in 1974.

Edwin Perkins received his BSc in mathematics from the University of Toronto in 1975 and his PhD from the University of Illinois–Urbana in 1979. He is currently Professor of Mathematics and holds a Canada Research Chair at the University of British Colombia, where he has been since 1979. He received the Rollo Davidson prize for young probabilists in 1983, and the Canadian Mathematical Society's Coxeter-James and Jeffrey-Williams Prizes in 1986 and 2002. He was elected Fellow of the Royal Society of Canada in 1988 and held an NSERC Steacie Fellowship in 1992–94.

Perkins has made outstanding contributions to several areas of probability theory and is one of the world's leading probabilists. Much of his early work concerned the delicate analysis of the sample of measure-valued diffusions, or "superprocesses," a field in the development of which he has been a pioneer. His accomplishments include deep and surprising results about the support of super-Brownian motion, including the identification of its Hausdorff dimension, the identification of the historical process as the correct way to understand genealogy in superprocesses, and the construction of a class of interacting superprocesses.

Carl Riehm (Fields Institute)

Quantitative Finance Seminars: Hedge Funds and Risk Management

Hedge funds were the topics of Don Lindsey and Myron Scholes in the January 30, 2003, seminar, which was sponsored by Sigma Analysis and Management, the Institute's first business off-shoot. Lindsey, president of the University of Toronto Asset Management Corporation, spoke on *Investment Darwinism: Hedge Funds and the Evolution of Investment Management*. He offered a perspective on current investment options and the value that alternative investments, such as hedge funds, can bring to a situation dominated by uncertainty. His thesis was that, in a world with increased uncertainty, creative thinking is more than ever a fundamental ingredient in managing complex investment portfolios.

Scholes, Professor Emeritus of Finance at the Stanford University Graduate School of Business and a Nobel Prize winner in economics in 1997, spoke on *Liquidity, Chaos, and Hedge Funds*. The main theme of his talk, which focused on risk management issues, was the concept of "salient" events, as opposed to repetitive events, as a basic target to be examined for active management purposes in addition to obvious, historical events.

The seminar was attended by an overflow audience from the local academic community and the business sector. The vigorous question period gave an indication of their curiosity in non-traditional investments, and in the recent increased activity by the investment community in incorporating hedge funds into their portfolios.

On February 19, Quantitative Techniques in Risk Management were the focus of David Heath (Carnegie Mellon) and Phelim Boyle (Waterloo), two authorities on financial mathematics.

Heath started the evening with a talk on *The Consistency of Two Markets*, a joint work with Hyejin Ku. He considered two financial markets with no arbitrage between them, and assumed that no one trades in both markets and that any claim traded in both markets trades at the same price. He concluded that, if someone could trade in both markets, one could construct new claims consisting of sums of claims in the two markets at prices equal to the sum of their market prices. He posed a question—"Under what conditions will this new trader be unable to construct an arbitrage?"—and went on to provide additional conditions under which this holds, as well as two interesting examples. Heath's talk helped to shed light on the theoretical nature of "no arbitrage pricing," and to serve as a wake-up call to institutional investors who use inconsistent pricing models across different trading desks.

Boyle then spoke on *Embedded Options in Insurance Contracts: Guaranteed Annuity Options*, a joint work with M. Hardy. He discussed the risks that arise when insurance companies include financial guarantees and other embedded options in their pension and insurance products. Under a

guaranteed annuity option, an insurer guarantees to convert a policyholder's accumulated funds to a life annuity at a fixed rate. If the annuity rates provided under the guarantee are more beneficial to the policyholder than the prevailing rates in the market, the insurer has to make up the difference. These guarantees were popular in the U.K. in the 1970s and 1980s when long-term interest rates were high. At the time of issue, the options were very far out of the money, and insurance companies assumed that interest rates would remain high and thus the guarantees would never become active. But in the 1990s, when long-term interest rates began to fall, liabilities under the guarantees began to rise. Two other factors adding to the cost of guarantees, Boyle said: strong stock market performance meant that the amounts to which guarantees applied increased significantly; and the mortality assumption implicit in the guarantees failed to anticipate the improvement in mortality which occurred. He went on to describe such guarantees and analyse their pricing as well as prudent risk management practices, after which the floor opened for a lively discussion.

These talks were part of the process of bringing closer together the actuarial insurance and financial economic fields of research—a primary mandate of the IFID Centre.

The analysis of risk management continued on April 30, when Thomas C. Wilson, head of Finance and Risk, Oliver Wyman and Co., spoke on *Valuing Financial Institutions: Integrating Internal and External Metrics* and David R. Koenig, chair PRMIA Board of Directors, discussed *Multiple Points of Failure: A New View on Risk Management.*

The Fields Institute would like to thank all speakers for their stimulating presentations.

Luis Seco (Sigma) and Moshe Milevsky (IFID)

Mathematics Education Forum

Four themes emerged in mathematics education this year: first, the major provincial initiative on K–3 mathematics teaching and learning; second, development of online mathematics learning; third, bridging for mathematics teachers in secondary or post-secondary programs, as the latter prepare to receive the graduates of the new Grade 12 program; fourth, the development of Working Groups for the CMS Forum on School Mathematics (May 16–18, 2003, in Montreal).

Initiated in 2002 by the Provincial Government, an expert panel chaired by Ruth Dawson and Chris Suurtam released its report, *The Ontario Early Math (K–3) Strategy*, in February 2003. Faced with this major report, the Mathematics Forum struggled to understand mathematics in the early childhood years—a new experience for many members. Two meetings focused on it: one, led by Marg Warren, Trevor Brown, and George Gadanidis, explored in-service models for elementary mathematics teachers; in the other, Chris Suurtam highlighted the findings of the expert panel's report. The balance of that agenda, led by George Gadanidis and Eric Muller, explored the "big ideas" of mathematics in the early years.

The Task Force on On-Line Mathematics Learning (Stewart Craven, George Gadanidis, Lynda Graham, Douglas McDougall, and Geoffrey Roulet) continued its activity, February 27–March 1, 2003. The meeting began with well-attended public lectures by Seymour Papert and Alan Kay. Then, a group of forty invited participants met to hear Bill Muirhead, and to tackle various questions raised by the organizers.

This is the year of the double cohort in Ontario, when students in the OAC Program (13 years) will graduate alongside those from the new Grade 12 Program. Postsecondary institutions are planning their courses and programs to meet this challenge, which is especially pronounced in mathematics. Students graduating from the Grade 12 program and going into mathematics-intensive postsecondary programs will have, on average, two fewer courses than their OAC counterparts. Their preparation in mathematics will also be different in approach. Their program places greater emphasis on concept development and requires more facility in the use of technology. The Forum brought together secondary and postsecondary mathematics educators to facilitate communication and to develop a better understanding of the transition. One of its meetings, organized by Shirley Dalrymple and Silvana Simone, provided a comparison of the two groups of students. Representatives from all Ontario University Mathematics Departments were invited to attend in order to gain some insights into the mathematical strengths that each group of students is likely to present, to hear about the use of technology in the new mathematics program, and to be informed about assessment in terminal courses.

The Fields Forum was well represented at the Montreal CMS Forum on School Mathematics, a matter of importance, as many of these individuals will be directly involved with the organization of the next meeting to be held in Toronto in 2005. Part of a Fields Forum meeting explored how working groups could look ahead in order to plan activities and projects that could be undertaken between the two meetings.

I continue to be amazed and impressed by the dedication of the many mathematics educators who give a Saturday every month to meet and work to improve mathematics education. The Fields Mathematics Education Forum is unique in the way it brings together mathematics educators from primary, secondary, and postsecondary institutions as well as individuals from the publishing and other industries.

Eric Muller (Brock)
Co-chair, Fields Mathematics Education Foru

Mathematics Online

The rapidly changing interface between education and information technology has been a topic of great interest at the Mathematics Education Forum. In November 2001, a working meeting was held on this theme, and a White Paper entitled *Online Mathematics: Visions and Opportunities, Issues and Challenges, and Recommendations* was published in the fall of 2002. From February 27 to March 1, 2003, the Institute hosted a follow-up gathering on the theme *Mathematics Online: Present Examples and a Look to the Future*. The meeting, open to the general public, began Thursday evening with keynote addresses from two pioneers in the field, Seymour Papert of MIT and Alan Kay, President of the Viewpoints Institute, who is widely known for his imaginative work over the years at Xerox, Atari, Apple, Disney, and Hewlett-Packard. Their joint message, illustrated by a carefully chosen and persuasive set of historical and contemporary examples, was that computers, in the hands of knowledgeable teachers, can be powerful tools for engaging learners in significant mathematical activity.

These talks (and the diverse, spirited discussion that followed) provided an effective backdrop for the deliberations of some forty members of the Forum during the next two days. Participants were representative of the varied subgroups of the Ontario mathematics education community—classroom teachers, board consultants, college and university mathematics professors, faculty of education instructors, and employees of major publishing firms.

Bill Muirhead, Director of Learning Technologies at the new University of Ontario Institute of Technology, began the Friday sessions with a comprehensive analysis of the recent history and current state of educational initiatives that incorporate significant elements of information technology. Drawing on his many years of experience in Alberta and his numerous international contacts, Muirhead made a strong case for standards and co-operation in the development of computer-based educational materials. He also suggested that the term "web-enhanced" was frequently a more accurate one than "online" to describe current initiatives. The group was particularly interested in his remarks about cross-institutional collaboration because in many ways his recommendations paralleled the evolution of the Education Forum at the Institute with its emphasis on bringing together ideas from different groups and institutions that share some common goals.

Most of the rest of the meeting was devoted to the discussion of three questions. The first was "what is happening online that we like?" In preparation for this session, participants had been invited during the previous two weeks to explore a number of different examples of online materials ranging in scale and type, including several developed by members of the group. The second question was "what do we want to do online in terms of mathematics education?" The final question, discussed in small groups of individuals with common interests, asked "how would we design an exemplary online activity?" A sharing of some of the preliminary efforts of the different groups to answer these questions and a general discussion of the major points of agreement that had emerged over the two days brought this stimulating and enjoyable gathering to a close at lunch-time on Saturday. Considerable material related to the meeting, in particular the first White Paper and the Papert–Kay talks, is currently available at www.fields.utoronto.ca/programs/mathed/meforum/online/. Further documentation of the gathering will appear there in due time.

William Higginson (Queen's)

Math Online Working Group

University of Ottawa: Now a Principal Sponsoring University

The Fields Institute is pleased to announce that the University of Ottawa has become a principal sponsoring university of the Institute, joining McMaster University, the University of Toronto, the University of Waterloo, the University of Western Ontario, and York University. Ottawa will run "Fields Institute Summer Schools" each year—this summer in Logic and Foundations of Computing (June 2–20, 2003). It will consist of two weeks of graduate courses, followed by a week of workshops. The organizers are Philip Scott, Richard Blute, and Peter Selinger, all of the Department of Mathematics and Statistics at Ottawa. See the School website www.mathstat.uottawa.ca/lfc/fields2003/ for more information.

Typus Geometrie, woodcut (artist unknown), in Gregor Reisch, *Margarita philosophica* (1512), an early encyclopedia of music, natural philosophy, astronomy, arithmetic, and geometry. The engraver represents the importance of geometry to navigation. Reproduced by permission of the Thomas Fisher Rare Book Library, University of Toronto.

Recent Fields Institute Publications

See: *www.fields.utoronto.ca/publications/index.html*

Communications Series

Vol. 35 *Symplectic and Contact Topology*, ed, Y. Eliashberg, B. Khesin, and F. Lalonde, University of Toronto, AMS, 2003, 199pp.

Vol. 36 *Dynamical Systems and Their Applications to Biology*, ed, S. Ruan, J. Wu, and G.S.K. Wolkowicz, McMaster University, AMS, 2003, 268pp.

Vol. 37 *Novel Approaches to Hard Discrete Optimization*, ed, P. Pardalos and H. Wolkowicz, University of Waterloo, AMS, 2003, 181pp.

Monograph Series

Vol. 18 *Meromorphic Functions and Linear Algebra*, by O. Nevanlinna, Helsinki University of Technology, AMS, 2003, 136pp.

Vol. 19 *Efficient Graph Representations*, by Jeremy P. Spinrad, Vanderbilt University, AMS, 2003, 342pp.

John W. Crow

We are pleased to welcome John W. Crow as a member of the Fields Institute.

John Crow, English-born and Oxford-educated, forged his career in the world of public service and finance. After a number of years with the International Monetary Fund, he joined the Bank of Canada, our country's central bank, and was its Governor for a seven-year term ending in 1994. He has remained active in the international community as an advisor to the IMF and other bodies. In addition, he is the author of *Making Money: An Insider's Perspective on Finance, Politics, and Canada's Central Bank (2002)*.

John has extensive interests in a number of directions. He is a Senior Fellow of the C.D. Howe Institute, and very much involved in the governance of arts groups, both national and municipal. He has a keen appreciation of the importance of an active interface between the academic community and the world of applications.

John Gardner (Chairman of the Board, Fields Institute)

John Crow

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

Donald Coxeter (1907–2003)

It is with great regret that we note the passing, on March 31, 2003, of H.S.M. "Donald" Coxeter (Professor Emeritus, University of Toronto). Donald Coxeter's name has been associated with the Fields Institute in many ways. He was the first recipient of both a Distinguished Service Award by the Institute (1993) and of the CRM–Fields Prize (1995). He was one of the original Fields Institute Fellows, an honour established last year. The Coxeter Lecture Series, inaugurated in 1997, has brought to the Institute many of the best-known researchers working at the forefront of mathematics. As mentioned below, Coxeter and his daughter Susan Thomas have generously made their home available to young mathematicians visiting the Institute.

The Institute setting has been greatly enhanced by two sculptures donated in celebration of Coxeter's ninetieth and ninety-fifth birthdays. The first, a realization by John Robertson of Borromean rings entitled *Intuition*, is located in front of the Fields building. The second, a geometric polytope mobile by artist Marc Pelletier, is suspended from the ceiling of the atrium of the Institute. It represents the orthogonal projection into 3-space of a polytope which is a 4-dimensional cousin of the regular dodecahedron, and so is especially appropriate as a tribute to Donald Coxeter.

Carl Riehm (Fields Institute)

Intuition, a Sculpture of Borromean Rings

Fields Plaque at Coxeter House

In recognition of Donald Coxeter's distinguished service to mathematics over a long professional life, on December 11, 2002, the Fields Institute affixed a plaque to his home, Coxeter House, an historically significant house in Toronto's Rosedale area. The dedication on the plaque reads: "Coxeter House, built 1935. Mackenzie Waters, architect. Longtime home of H.S.M. 'Donald' Coxeter, OC (Order of Canada), Canada's renowned geometer. Presented in appreciation by the Fields Institute for Research in the Mathematical Sciences." A champagne and hors d'oeuvre reception followed. In attendance were Donald Coxeter and his daughter, Susan Thomas, Ken Davidson, Bradd Hart, and Alison Conway, representing the Fields Institute, and John Friedlander and Arthur Sherk, colleagues of Coxeter's in the Mathematics Department at the University of Toronto.

The Coxeters have generously made available accommodation in their home to visiting Fields members. Their first mathematical guest was Trevor Irwin, a graduate student participating in the Set Theory Program, who also attended the dedication of the plaque.

Alison Conway (Fields Institute)

Bradd Hart

On July 31, 2003, Bradd Hart will step down from his position as Deputy Director of the Fields Institute, a post he has held since 1999, and return to McMaster University, where he is Professor of Mathematical Sciences in the Mathematics and Statistics Department.

Bradd's work at the Institute has been of critical importance. He has provided leadership in many different spheres of activity here—staff management, education, the commercial and industrial programs, and the welfare of the many research-oriented activities of the Institute, and has been highly effective in building bridges with the world of applications. In addition, he carried the Institute as Acting Director for the full 2000–2001 year during the long search for a replacement for Don Dawson.

Immediately after his assumption of the Deputy Directorship, Bradd played a key role in reorganizing the management structure for finance and operations of the Institute. Since that time, he has brought about complete overhauls of our database and our website. The smooth day-to-day operation of the Institute is in large part due to his diligence.

Under Bradd's guidance, the Mathematics Education Forum experienced a dramatic increase in its activity and influence that has seen it develop into a significant force in mathematics education in Ontario and in Canada. Notable activities include the development of Working Groups dealing with implementation of the new Ontario high school mathematics curriculum, development of Fathom workshops, and working with the CMS on a national meeting in Montreal in May 2003. Another development in education under Bradd's stewardship has been the encouragement of JUMP, a volunteer-based registered charity, now housed at the Institute, which organizes and provides free math tutoring to elementary students in lower-income areas across Toronto.

Bradd also played a critical role in the ongoing development and growth of the Fields Commercial/Industrial Mathematics program. Indeed, Fields has increased the number of its corporate sponsors from three to ten over the past few years. This has resulted in a corresponding increase in CIM activities. In particular, the monthly finance seminar continues to increase in popularity. He has helped a number of groups develop MITACS projects. And a collaboration has been developed with CIRANO to offer professional short courses in finance. Bradd also brought two mathematical finance start-up companies to Fields—Sigma Analysis and Management and the IFID Centre—both of which have grown into flourishing enterprises. He has recently been working to establish an Industrial Advisory Board to help the Institute develop in these areas.

Bradd Hart

Scientific activities at the Institute are our bread and butter, and Bradd has played a key role here as well, working with mathematicians from across Canada and around the world to develop excellent programs here at Fields and at our sponsoring universities. The list of activities is too long to mention.

Bradd received his undergraduate education at the University of Waterloo and a PhD from McGill University in 1987, after which he held a postdoctoral fellowship at the University of California at Berkeley. He was awarded an NSERC University Research Fellowship in 1989, at which time he joined McMaster University. He has held visiting positions at the Mathematical Sciences Research Institute in Berkeley and at the University of Illinois at Chicago.

Bradd's own research has been primarily in model theory, more specifically in stability and simplicity theory. In 1996–97, he was an organizer of a thematic year in Algebraic Model Theory at the Fields Institute, and has also been active in organizing many other special events with the CMS and with the Association of Symbolic Logic, on whose Executive Council he serves as a member. He was a plenary speaker at the European Logic Colloquium in 1998. He is a co-organizer of a regular and very successful seminar at the Institute devoted to complexity theory and model theory.

Bradd's enthusiasm is infectious. We all owe him a debt of gratitude for his many contributions to the Institute and hope that he will continue to play a strong role in our future. Everyone at the Fields Institute holds him in great affection, and we wish him the very best in the future.

Kenneth R. Davidson (Director, Fields Institute)

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