

# THE FIELDS INSTITUTE FOR RESEARCH IN MATHEMATICAL SCIENCES

## Annual Report 1999

### The Mission...

The Fields Institute is a hub for innovative research ideas in the mathematical sciences in Canada.

Our mission is to provide a supportive and enriching environment for researchers and their work and to encourage a collaborative exchange of ideas between the world's foremost innovative thinkers in mathematics.

Through our industry partners and network of supporters in education, technology, finance and medicine, we aim to promote the advancement of the mathematical sciences.

Primarily, we seek to influence the use of mathematics in Canadian society, to influence the world-view of Canadian mathematicians and to build a community that will impact the world through mathematics.

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# Institute Profile

The Fields Institute for Research in Mathematical Sciences was created in 1991 and incorporated in 1994. The Institute serves as a focal point for collaboration between mathematicians and other scientists, and for connecting mathematicians to industry and the community.

Our objectives are:

- to bring together leading mathematical scientists from around the world for periods of intensive collaboration with Canadian researchers, postdoctoral fellows and graduate students,
- to help train a new generation of mathematical scientists at the forefront of emerging areas,
- to promote communication and collaboration between mathematicians, statisticians, computer scientists and industry within a broad spectrum of disciplines including engineering, physics, chemistry, biology, economics, finance, telecommunications and medicine,
- to contribute to quality mathematics education, and provide a meeting place and resources for mathematics educators at all levels, and
- to develop programs that promote public awareness of mathematics in Canada.

Our research activities bring together prominent mathematicians from Canada and around the world for periods of intensive collaboration on topics of current importance. Unique courses, seminars, and other activities offer Canadian and international graduate students and postdoctoral fellows access to world leaders and gives private sector mathematical scientists access to the latest developments. Programs are selected by an independent group of leading Canadian and international mathematicians, known as the Scientific Advisory Panel.

The Institute supports research in pure and applied mathematics, statistics, computer science, engineering, biology, theoretical physics, economics, finance, telecommunications, and medicine. We provide office space for 78 visitors, a 100-seat lecture room and a smaller board/seminar room, an atrium for casual gathering and hospitality space for informal collaboration, and the James Stewart Library.

The Fields Institute is funded by the Ontario Ministry of Education and Training and the Natural Sciences and Engineering Research Council of Canada. Our four Principal Sponsoring Universities and our ten Affiliate Universities provide a strong scientific base.

## Principal Sponsoring Universities

McMaster University, the University of Toronto, the University of Waterloo and York University.

## Affiliated Universities

Atlantic Association for Research in Mathematical Sciences - made up of Dalhousie University, Memorial University of Newfoundland and the University of New Brunswick, the Ottawa-Carleton Institute for Mathematics and Statistics, Queen's University, the University of Guelph, the University of Manitoba, the University of Saskatchewan, and the University of Western Ontario.

# Message from the Chair...

Since its conception in 1991, the Fields Institute has grown in reputation and impact. The 1998-99 year was no exception. We have achieved a new level of significance to the Canadian mathematical sciences community through our highly successful thematic programs, our workshops, conferences and off-site presentations in the general and mathematical sciences, our support of other Canadian mathematical societies, and our work in mathematics education. By building stronger relationships with our funding agencies, we were able to provide increased support for research activities. We have continued to strengthen our relationships with the financial and industrial sectors through our seminar series. And through the development of new industry partnerships, we have entered a new realm of academic-industrial research interaction.

The process of renewing our relationship with the Natural Sciences and Engineering Research Council of Canada (NSERC) last year provided a unique opportunity for the mathematical sciences community to demonstrate their commitment and give testimony to the importance of the Institute to their work. Over 100 people provided input to the NSERC Site Visit Committee. The process resulted in an increased level of support from the agency. As well, representatives from the Ontario Ministry of Education and Training (OMET) participated in the NSERC site visit and through subsequent negotiations with them the Institute was successful in securing a four-year contract that stabilized our funding. Our success in gaining extended support at an increased level is a direct result of the recognition of the integrity and importance of our research and activities.

Under the direction of Deputy Director, Bill Langford, the Fields Institute supported the design and the writing team that revised the Ontario secondary school mathematics curriculum. It was the team that won the contract, while the Institute provided consulting services, space and administrative support. A team of thirty mathematics educators completed the rewriting of the curriculum in autumn 1998. The ministry accepted the proposal and the new curriculum will be implemented into secondary schools in Ontario this September.



We took advantage of our new contacts in the financial industry and presented the Probability and Its Applications program that included an extremely successful workshop “Probability in Finance”. Over 285 individuals drawn from both financial and academic communities attended this workshop. The demand for this program, from Canadians and individuals from other countries, was so high that the workshop site had to be shifted to the Royal Ontario Museum lecture hall.

The Fields Institute, along with the Centre de recherches mathématiques and the Pacific Institute for the Mathematical Sciences, was successful in securing funding for a proposal to create a mathematical national centre of excellence. This resulted in the signing of the Mathematics of Information Technology and Complex Systems (MITACS) Network Agreement on February 22, 1999. With the start of this new centre of excellence, the opportunities for academic-industrial interaction have greatly expanded. The Fields Institute looks forward to working with the MITACS staff and researchers to bring about exciting developments.

Financially, the 1998-99 year was also successful. We were able to set aside the deferred revenue needed to complete the program for the current academic year, to generate a surplus on operations for the year, and to reduce the accumulated deficit. In addition, for the first time we were able to present the results of our financial performance in the traditional format of a balance sheet and a statement of income and expenditures. These

statements, together with the auditor's letter, are presented at the end of this report.

While the impact of the Fields Institute is broad and growing, the human resources behind it are small in numbers but strong in energy and commitment. On behalf of all the members, I would like to thank the Staff, the Board of Directors, and the Director. Their effort has made these accomplishments possible.

I would especially like to single out our Deputy Director Bill Langford, who will be retiring from his position in September. Bill's dedication and enthusiasm has made a big difference to the Institute. The province owes Bill a great deal for the successful undertaking of the Ontario Secondary School Mathematics Curriculum project.

Finally, we must not forget that it is the support from our major financial backers, the Ontario Ministry of Education and Training, the Natural Sciences and Engineering Research Council of Canada, and our member universities that enable the Fields Institute to exist. To them I extend our collective thanks and appreciation.

John Gardner

# Message from the Director...



In assessing the impact of the Fields Institute on the mathematical sciences community this past year, once again we can be proud of its many achievements. We undertook a variety of special on-site activities and joint sponsorship of research activities across Canada in cooperation with other research institutes and mathematical sciences societies which broadened the scope of the Institute's interests and set us off in new directions.

Locally, the highly successful thematic program in Probability and Its Applications was the major activity which brought over 750 participants to the Fields Institute to focus on current research directions in probability and stochastic analysis together with their applications to statistical physics, telecommunications, finance and biology. Leading researchers in each of these areas participated in a series of workshops that provided the participants and particularly the younger researchers with unique opportunities for collaboration. The postdoctoral fellows and the graduate students played a key role in creating an exciting environment. The program offered five graduate courses, three mini-courses and eight workshops, which created unique opportunities to learn about some of the latest advances in percolation, Monte Carlo simulation, large deviations, mathematical finance, Brownian motion, computational stochastics, superprocesses and population genetics. The monthly Kolmogorov lectures brought ten of the leading international probabilists to the Institute to present surveys of the major directions of research in probability. The

program also provided striking examples of the impact mathematics has on business and industry. The program included a spin-off one-day workshop on communications networks at Nortel Networks in Ottawa with a record-breaking attendance of over 285 individuals at the Probability in Finance workshop in January and over 140 international participants in the North Atlantic Treaty Organization Advanced Studies Institute in Mathematical Problems Arising in Biology.

A number of special on-site activities complemented the main program and included Nobel Prize winner, Pierre-Gilles who gave an informative series of lectures on statistical physics and a wonderful public lecture on the dynamics of sand dunes as part of our Distinguished Lecture Series. Leading probabilist Richard Durrett of Cornell University gave a series of lectures on probabilistic models in molecular biology, population genetics and ecology in our Coxeter Lecture Series. The 1998 CRM-Fields Prize recipient, Professor Robert Moody of the University of Alberta lectured on his explorations of aperiodic order. The three monthly seminar series in Mathematical Finance, Industrial Mathematics and Applications of Statistical Science brought people from many fields of interest and from the academic, business, industry and health-care sectors to the Institute. Our first open house provided undergraduates the opportunity to learn about the wealth of graduate programs available in the mathematical sciences at our partner universities. Over 130 participants in academia, government and industry came to the Conference on the Mathematics of Public-Key Cryptography in June to examine and probe computational complexity and implementation issues important in this approach to information security.

The Institute was again involved in supporting the Canadian mathematical science societies and many conferences and workshops across the country. A new level of cooperation among the three institutes, CRM, The Fields Institute and PIMS has been achieved with the creation of the National Program Committee of the Canadian Mathematical Sciences Research Institutes. The program will provide a framework for joint sponsorship of research activities across the country and major international initiatives such as the First Canada-

China 3X3 Mathematics Congress.

The Fields Institute continues to play a key role in bringing together mathematics educators from all levels to work together on the needs of our educational system as we enter the new millennium. Our contribution to mathematics education in Ontario was recognized federally, provincially and locally. In the summer of 1998, a team of mathematics educators worked at the Institute to write the curriculum policy document, which sets out the new mathematics curriculum for Ontario high schools. The Fields Institute, under the direction of the Deputy Director, Bill Langford, served as the contractor for the project and provided support during the proposal stage and the contract stage.

We played a key role in creating and operating MITACS, a new mathematics institution, which will serve as an important tool in the development of university-industry research partnerships in the mathematical sciences. With funding from the federal Networks of Centres of Excellence program, MITACS officially began operations in February and ushered in a new era in Canadian mathematics.

The successes of the past year have been made possible by the contributions of many individuals and organizations. The Board of Directors and Corporate Members provided sound financial management to ensure that the Institute's programs met the needs and priorities of our many stakeholders. The high quality of the Fields Institute's scientific programs owes much to the guidance of our Scientific Advisory Panel and in particular I would like to acknowledge the important contributions made by the retiring members David Brillinger, Vaughan Jones and Jerrold Marsden. Special thanks are due to the organizers of the Probability program, Neal Madras (York University), Thomas Salisbury (York University) and Gordon Slade (McMaster University), for their energy and dedication throughout the past 18 months. Organizers and participants alike expressed their thanks to the Fields Institute staff for making everything work smoothly even at the most hectic times. Finally, I would like to add my personal thanks to Bill Langford who has contributed much to the Institute over the past three years and provided leadership at a critical time for the future of mathematics education in Ontario.

The next year will be an exciting and eventful year for Canadian mathematics and the Fields Institute and I look forward to the challenges and new opportunities that are on the horizon. The year will start off with the first Canada-China 3X3 Mathematics Congress in Beijing in August. The thematic program on Graph Theory and Combinatorial Optimization will run from September through May. In autumn we will also feature the mini-program on Causal Interpretation and Identification of Conditional Independence Structures. As part of World Mathematical Year 2000, there will be a series of special events in June highlighted by the Fields Symposium on the Legacy of John Charles Fields, the first annual meeting of MITACS in Toronto, followed by the joint annual meeting of a number of Canadian mathematics organizations; including, the Canadian Mathematical Society, and the Canadian Applied and Industrial Mathematics Society in Hamilton.

Donald A. Dawson

# Message from the Deputy Director...

This report marks my last annual message as Deputy Director of the Fields Institute, as I will complete my three-year term and return to my professorial duties at the University of Guelph in September. This year has been especially exciting for me and for the Institute. A great deal has been accomplished. As Deputy Director, I have been able to serve as a catalyst to the efforts of many individuals in the local mathematical community and abroad. The Fields Institute enables Canadian mathematicians to achieve objectives otherwise unattainable if they acted alone. A prime example is the Ontario Secondary School Curriculum Policy document for mathematics, a project for which the Fields Institute bid and won the contract, then assembled a talented writing team to produce an outstanding new secondary school mathematics curriculum for Ontario.

As I contemplate leaving the Institute, I cannot help but reflect on the events of the decade that has passed since its conception. Ten years ago, the dream of establishing the Fields Institute was dismissed by all but a few highly dedicated individuals – Jerrold Marsden, William Shadwick, John Chadam and Carl Riehm – among others. Now, as we approach the second decade in the life of the Fields Institute, let us not forget these pioneering visionaries. The Institute has obtained secure funding from both the provincial and federal governments, a beautiful building ideally suited to its purposes, an international reputation for high-quality research and the growing respect of the educational and industrial communities. The Fields Institute has been a major factor in a new national appreciation for Canadian mathematics, which has led to an increase in funding for mathematics across the board. The success of the Fields Institute has led others to follow in our footsteps. I am proud to have played a part in the achievements of the



Institute. I would like to take this opportunity to congratulate Donald Dawson for his leadership in the outstanding success of the Institute programs and its role in the advancement of Canadian mathematics. I wish the Institute continued success as it celebrates the World Mathematical Year, as declared by UNESCO and the International Mathematical Union.

William Langford

# THEMATIC PROGRAM

## Probability and Its Applications August 1998 - July 1999

Probability theory is a part of mathematics in which a large amount of primary research activity takes place. It is also an area with many applications outside of mathematics. The program in “Probability and its Applications” combined the two sides of the subject, through concentrating on aspects of mathematical research in probability that are currently the focus of applications outside mathematics. This was evident in the four topics of concentration: Physics, Communications, Finance and Biology. Besides these topics, many links with statistics, partial differential equations, theoretical computer science, and numerical analysis were explored.

The year’s activity consisted of eight workshops, several shorter meetings, three series of lectures by distinguished probabilists and other scientists, a weekly seminar series, five graduate courses, and two short courses. Nine postdoctoral fellows spent the bulk of the year at the Institute. Many graduate students from the Toronto area participated in the program, in addition to which six students from other locations received funding to spend a term in residence at the Institute.

A significant number of the world’s leading probabilists were at the Institute at some point during the year, either attending one of the workshops, giving a lecture, or making an extended visit. Nine probabilists from local universities were present for the entire year, and visitors made stays ranging from a few days to several months. For example, nine probabilists (Pradeep Banerjee, Frank den Hollander, Rimas Norvaisa, Edwin Perkins, Steve Evans, Takashi Hara, Matthew Penrose, Raj Srinivasan, and Remco van der Hofstad) were in residence for two months or longer. Much of the year’s activity was planned around bringing people together, to exchange ideas, or to conduct collaborative research. This atmosphere was particularly stimulating for the graduate students and postdoctoral fellows who, so early in their careers, had a unique opportunity to interact with such a broad range of established researchers.

**Organizing Committee:** D. Dawson (Fields Institute), N. Madras (York University), T. Salisbury (York University), G. Slade (McMaster University).

**Program Committee:** D. Dawson (Fields Institute), G. Grimmett (University of Cambridge), T. Lyons (Imperial College), T. Kurtz (Wisconsin University), N. Madras (York University), E. Perkins (University of British Columbia), T. Salisbury (York University), G. Slade (McMaster University), S. R. S. Varadhan (Courant Institute).

## Activities

### August - December 1998

Topics of concentration:

Probability and Physics  
Probability and Communications

The main activity in the autumn term centered around the three graduate courses and four workshops listed below. The topics of the courses and workshops were closely linked. In many cases the courses aimed to establish connections between various workshop topics.

#### Graduate Courses

Large Deviation Theory: Introduction and Applications

Frank den Hollander (University of Nijmegen) gave a course on Large Deviation Theory. This concerns the systematic evaluation of probabilities of rare events, in which some random quantity attains a value unusually far from its mean. Many problems in reliability of communications networks can be expressed in these terms and indeed, large deviations arose in virtually every one of the autumn workshops. For example, they are intimately connected with the analysis of integrals of exponential functions, which are widespread in statistical physics.

Monte Carlo Methods

Neal Madras (York University) taught Monte Carlo Methods. This course studied theoretical properties and practical issues of these computer simulation methods. It highlighted the power and diversity of Markov chain methods, used for decades in statistical physics, and more recently in Bayesian statistics and theoretical computer science. This course was taken for credit by students from departments of mathematics, statistics, chemistry, and physics, and audited by people from computer science and management. These methods were the specific topic of one of the autumn workshops, but they also played an important role in the winter session, particularly during the workshops on Numerical Methods and on Mathematical Problems in Biology.

Percolation

Gordon Slade (McMaster University) taught a course on Percolation, so called because the ideas can be used to model oil percolating through rock. Mathematical percolation is a simple model of a random medium, and yet it offers many challenges to mathematician and physicist alike. In the most common version, edges in an infinite graph are randomly deleted with probability  $q$  each. The existence of a remaining infinite connected component depends sensitively on the value of  $q$ , and is the simplest example of a “phase transition” in physics. This model has been of central importance in the development of the statistical mechanics branch of modern probability theory.

## Workshops

### Workshop on Mathematical Physics of Polymers and Percolation

August 24-29, 1998

**Scientific and Organizing Committee:** J. Cardy (University of Oxford), F. den Hollander (University of Nijmegen), G. Slade (McMaster University) and S. Whittington (University of Toronto).

#### **Speakers:**

M. Aizenman (Princeton University)  
M. Batchelor (Australian National University)  
M. Bousquet-Melou (Université Bordeaux 1)  
C. Borgs (Microsoft Research)  
A. Burchard (Princeton University)  
J. Cardy (Oxford University)  
J. T. Chayes (Microsoft Research and University of California, Los Angeles)  
A. J. Guttmann (University of Melbourne)  
T. Hara (Tokyo Institute of Technology)  
F. den Hollander (University of Nijmegen)  
E. J. Janse van Rensburg (York University)  
G. Lawler (Duke University)  
A. Owczarek (University of Melbourne)  
A. Pisztor (Carnegie Mellon University)  
Y. Saint-Aubin (Université de Montréal)  
H. Saleur (University of Southern California)  
G. Slade (McMaster University)  
T. Spencer (Institute for Advanced Study)  
S. G. Whittington (University of Toronto)

The first workshop of the autumn term was Mathematical Physics of Polymers and Percolation. Percolation was the subject of Gordon Slade's course mentioned above, and 'polymers' refers mainly to self-avoiding walks and other discrete models of large flexible polymer molecules. These two topics have many intimate interconnections: often methods that work for one model can be adapted to analogous questions about the other. Both topics abound with basic questions that can only be solved using nonrigorous methods of theoretical physics; however, in the last two decades, mathematicians have made important contributions by obtaining rigorous proofs of some results that help to confirm the physical theories upon which the physicists' analyses are based. Among the most exciting areas now is the problem of conformal invariance of scaling limits of critical percolation, polymers, and other models in two dimensions. John Cardy, one of the workshop

organizers, is a physicist who has been at the forefront of studying conformal invariance; others who spoke on this topic at the workshop included Michael Aizenman, Almut Burchard, Greg Lawler, Yvan Saint-Aubin, and Hubert Saleur. Wendelin Werner during the seminar on Stochastic Processes in March revisited this topic.

### Workshop on Hydrodynamic Limits

October 5-10, 1998

**Organizing Committee:** S. Feng (McMaster University), A. Lawniczak (University of Guelph) and S. R. S. Varadhan (Courant Institute).

Preceding the workshop Professor S. R. S. Varadhan delivered a mini-course on Hydrodynamic Limits and Large Deviations on October 5 and 6.

#### **Speakers:**

J. Carrillo de la Plata (University of Texas at Austin)  
A. Deutsch (University of Bonn)  
G. Eyink (University of Arizona)  
H. Fuks (The Fields Institute and University of Guelph)  
T. Funaki (University of Tokyo)  
J. Gärtner (Technische Universität Berlin)  
R. Illner (University of Victoria)  
D. Levermore (University of Arizona)  
J. Quastel (University of Toronto)  
K. Ravishankar, (SUNY)  
F. Rezakhanlou (University of California, Berkeley)  
T. Seppäläinen (Iowa State University)  
H. Spohn (Ludwig-Maximilians-Universität München)  
H. T. Yau (Courant Institute)

The workshop Hydrodynamic Limits looked at questions involving the collective behaviour of a very large number of particles, each of which performs some kind of random motion, with various kinds of interactions between the particles. The main objective is to obtain appropriate macroscopic partial differential equations from microscopic laws that govern individual particles. Large deviation techniques play a crucial role here. This workshop brought theoreticians together with researchers who were primarily involved with computational aspects via cellular automaton models. In addition to the research level talks given as part of the workshop, a set of introductory lectures were given by S. R. S. Varadhan, unquestionably the leading expert in the mathematical

analysis of such problems.

## Workshop on Monte Carlo Methods

October 25-29, 1998

**Organizing Committee:** N. Madras (York University), R. Neal (University of Toronto) and J. Rosenthal (University of Toronto).

### Speakers:

B. Berg (Florida State University)  
J. Besag (University of Washington)  
D. M. Ceperley (University of Illinois)  
J. A. Fill (Johns Hopkins University)  
K. Jansen (CERN)  
A. D. Kennedy (University of Edinburgh)  
X.-L. Meng (University of Chicago)  
A. Mira (University of Minnesota)  
J. Möller (Aalborg University)  
D. Murdoch (University of Western Ontario)  
G. O. Roberts (University of Lancaster)  
A. Sinclair (University of California, Berkeley)  
S. G. Whittington (University of Toronto)  
D. B. Wilson (Microsoft Research)

The workshop Monte Carlo Methods was closely tied to the course of the same name. Rising to prominence in connection with the Manhattan project, such methods use random processes to get approximate answers to otherwise intractable problems. A significant fraction of the world's computing cycles are spent on such calculations, in areas such as finance and physics. The workshop focused on Markov chain Monte Carlo methods that have been used effectively in statistics and in physics (statistical mechanics as well as lattice quantum field theory). This was particularly timely because in the past few years there have been novel algorithms proposed in one of these fields that were successfully adapted for use in the other. To increase communication among these and other communities, the workshop offered several one-hour tutorials that included a formal introduction to the problems in the respective fields: one for statistics (Radford Neal), statistical mechanics (Stuart Whittington), and lattice field theory (Anthony Kennedy). One exciting recent development in Markov chain Monte Carlo has been methods of perfect sampling which achieve sampling from the limiting distribution of the chain in finite time with no theoretical approximation error. Jim Fill, Xiao-li Meng, Jesper Möller, and Duncan Murdoch spoke about perfect sampling; in addition, Radford Neal presented an introduction to perfect sampling for the many in the audience

for whom this was completely new. As a result, one of the participants in the poster session, David McDonald, discovered that he could adapt perfect sampling to his problem of simulating ATM switches in telecommunications networks.

## Workshop on Analysis and Simulation of Communication Networks

November 9-13, 1998

**Organizing Committee:** P. Glynn (Stanford University), D. McDonald (University of Ottawa) and R. Srinivasan (University of Saskatchewan).

### Speakers:

R. Atar (York University - Fields Institute)  
D. Daley (Australian National University)  
M. Devetsikiotis (Carleton University)  
S. Foss (Institute of Mathematics, Novosibirsk)  
P. Glynn (Stanford University)  
C. Graham (CNRS)  
S. Grishechken (Carleton University)  
A. Karasaridis (University of Toronto)  
F. Kelly (University of Cambridge)  
G. Kesidis (University of Waterloo)  
T. Kurtz (University of Wisconsin)  
W. Massey (Bell Labs of Lucent Technologies)  
D. McDonald (University of Ottawa)  
B. Prabhakar (Stanford University)  
M. Reiman (Bell Labs of Lucent Technologies)  
R. Srinivasan (University of Saskatchewan)  
D. Stanford (University of Western Ontario)  
Y.-C. The (Oxford University)  
S. Turner (Cambridge University)  
W. Whitt (AT&T Labs Research)  
R. Williams (University of California, San Diego)

The workshop "Analysis and Simulation of Communication Networks" considered the general problem of modeling how such networks respond to the loads put on them by the random arrival and departure of customers. This is a problem of continuing relevance in applied mathematics. The first two days of the workshop focused on stability and load balancing in a network of call centres (in which groups of operators service a huge number of incoming calls). Techniques of large deviations were of key importance here, especially in the talks of Ward Whitt, Marty Reiman, William Massey, and David McDonald; later in the conference, Frank Kelly, Rami Atar and Carl Graham also focused on large deviations analysis. The remainder of the work-

shop dealt with a wider array of issues in traffic modeling and performance analysis. Of particular note were talks on rate control by Frank Kelly and Thomas Kurtz, Peter Glynn's lecture on methods for inhomogeneous traffic, and Balaji Prabhakar's talk on using information theory to help design switches. Several conference participants were from industrial research groups (including AT&T, Lucent Technologies, Newbridge Networks, and Algorithmics Inc.). As part of the Fields Institute's mission of industrial outreach, one of the main speakers, Frank Kelly (University of Cambridge) gave a talk at Nortel Networks in Ottawa on the Friday preceding the workshop.

## Highlights

- The "Fields Distinguished Lecture Series", given by Pierre Gilles de Gennes, the 1991 Nobel Laureate in Physics. He gave two research seminars, including one about branched polymer molecules that tied in nicely with the August workshop. He also delivered a well attended public talk aimed at advanced high school students.
- Four lectures in the "Kolmogorov Lecture Series" (named after the founder of the modern theory of probability), given by eminent probabilists, and aimed to introduce new developments in Probability to non-specialists at surrounding universities. Three of the speakers, Geoffrey Grimmett, Harry Kesten and C. M. Newman, spoke on problems arising from statistical mechanics, while Béla Bollobás described problems of random graphs (one of the topics that will also be featured during the 1999-2000 thematic program Special Year on Graph Theory and Combinatorial Optimization).
- McMaster University's "Britton Lecture" series, given by David Brydges of the University of Virginia, on topics in statistical physics tied closely to the Fields program.
- A session on probability at the Canadian Mathematical Society's Winter Meeting in Kingston, organized by Miklos Csorgo. Thirty-two invited speakers surveyed the broad range of work in Probability taking place across Canada. The session was supported financially by the Fields Institute.
- Sixteen weekly seminar lectures by visitors and program participants.

# Activities

## January - June 1999

### Topics of Concentration:

Probability and Biology  
Probability and Finance

The main activities in the winter term were a pair of graduate courses, and four workshops, the last of which was conducted as a NATO Advanced Study Institute.

### Graduate Courses

#### Brownian motion, with Applications

Tom Salisbury (York University) taught Brownian motion, with applications. Originally developed as a model of a particle diffusing in a fluid, mathematical Brownian motion is now fundamental to virtually every branch of probability theory. Roughly two-thirds of the course was devoted to the basic theory of Brownian motion (including stochastic calculus), and a survey of its many uses. Since Brownian motion arose in every winter workshop the survey gave graduate students the background to understand the material being presented. The remaining third of the course gave a detailed treatment of conditioning and  $b$ -transforms.

#### Topics in Stochastic Analysis and the Mathematics of Finance

The course Topics in Stochastic Analysis and the Mathematics of Finance was given in four month-long modules, each devoted to a different topic in this area. Robert Elliott (University of Alberta) lectured in January on the use of discrete version of filtering theory in mathematical finance. He also spoke at the January workshop Probability and Finance. In February, Rimas Norvaisa (Vilnius Institute of Mathematics and Informatics) developed the theory and financial applications of  $p$ -variation based calculus. This topic reappeared in the April lectures by Terry Lyons (Imperial College), which showed how a suitable use of certain basic multiple integrals can be used to extend the stochastic calculus of Brownian motion to very general

“rough paths”. This topic was taken further in the April workshop on numerical methods. Donna Salopek (York University), who coordinated the entire course, gave the March lectures. She addressed the recent growth of links between insurance and the pricing theory for derivative securities.

## Workshops

### Workshop on Probability in Finance January 26-30, 1999

**Organizing Committee:** C. Albanese (University of Toronto), D. Dawson (Fields Institute), H. Föllmer (Humboldt Universität), P. E. Greenwood (University of British Columbia), T. Kurtz (University of Wisconsin), T. Lyons (Imperial College) and D. Salopek (York University).

#### **Speakers:**

M. Crouhy (Canadian Imperial Bank of Commerce)  
M. Davis (Mitsubishi Bank)  
F. Delbän (ETH, Zurich)  
R. Dembo (Algorithmics Incorporated)  
D. Duffie (Stanford)  
D. Dufresne (University of Melbourne)  
R. Elliott (University of Alberta)  
P. Embrechts (ETH, Zurich)  
H. Föllmer (Humboldt Universität - Berlin)  
H. Geman (Univ. Paris IX Dauphine & ESSEC)  
D. Heath (Cornell University)  
J. Hull (University of Toronto)  
I. Karatzas (Columbia University)  
A. Levin (Bank of Montreal)  
A. Lo (Massachusetts Institute of Technology)  
L. C. G. Rogers (University of Bath)  
S. Ross (Massachusetts Institute of Technology)  
S. Shreve (Carnegie Mellon University)  
S. Turnbull (Canadian Imperial Bank of Commerce)

**Contributed Talks:** T. Bielecki (Northeastern Illinois University), H. Shirakawa (Tokyo Institute of Technology), L. Overbeck (Deutsche Bank AG) and B. Hoejgaard (Aalborg University).

The first workshop of the winter term was Probability in Finance. It was immensely popular, attracting almost 300 participants, including many from the Canadian financial industry. The meeting was so large that it had to be moved from the Institute, to the theatre of the

Royal Ontario Museum. The material of the workshop was closely tied to both of the winter graduate courses, and reappeared in the Symposium on Numerical Stochastics in Finance, held in April. The enormous growth of mathematical finance as an academic discipline (including a pair of Nobel prizes for some of the original work in the field) has paralleled the growth of the derivative security market from very modest levels 25 years ago, to current (nominal) levels of trillions of dollars annually. Many of the leaders of the field spoke at the workshop, which in part accounted for its popularity. One high point of the meeting was the Kolmogorov lecture delivered by Hans Föllmer, which described a new generation of mathematical ideas now prominent in finance. Another was the lecture by Stephen Ross in the series of Fields Seminars in Financial Mathematics, which tied survivorship bias and conditioning to the perceptions of the failure of “Long Term Capital”. Topics addressed in the other talks included models of interest rates, credit derivatives, risk management, and the pricing of exotic options and other derivative securities. The workshop included a poster session and competition. As well, the currently hot topic of credit risk was the subject of a lively panel discussion.

### Workshop on Interactive Measure-Valued Processes March 8-12, 1999

**Organizers:** E. Perkins (University of British Columbia) and D. Dawson (Fields Institute).

#### **Speakers:**

S. Athreya (Fields Institute)  
T. Cox (University of Syracuse)  
J. Delmas (ENPC-CERMICS)  
R. (Cornell University)  
E. Dynkin (Cornell University)  
S. Ethier (University of Utah)  
S. Evans (University of California, Berkeley)  
K. Fleischmann (Weierstrass Institute for Applied Analysis and Stochastics)  
A. Greven (University of Erlangen)  
T. Kurtz (University of Wisconsin, Madison)  
S. Kuznetsov (University of Colorado)  
J.-F. Le Gall (École Normale Supérieure, Paris)  
Y. Le Jan (Université Paris Sud)  
V. Limic (University of California, San Diego)  
P. March (Ohio State University)  
C. Mueller (University of Rochester)

L. Mytnik (Technion)  
B. Schmuland (University of Alberta)  
J. Vaillancourt (Université de Sherbrooke)

Interactive Measure-Valued Processes was the title of the March workshop, though in fact the talks ranged over a wider area than this title would imply. Measure-valued diffusions or “superprocesses”, such as the Dawson-Watanabe process or the Fleming-Viot process, are one of the chief concrete examples of stochastic processes taking values in infinite-dimensional spaces. They also form the most widely studied class of solutions to stochastic partial differential equations (SPDEs), which have begun to attract some of the attention previously paid to ordinary SDEs. The talks spanned the field, from PDE techniques to the Brownian snake, particle system approaches, SPDEs, the coalescent, and genetics models. Some of the most striking results concerned SPDE models for superprocesses interacting via competition or catalysis. For example, Klaus Fleischmann spoke about work in progress on a model for mutually catalytic super Brownian motion. When completed, the paper will have at least six authors (Don Dawson, Alison Etheridge, Klaus Fleischmann, Leonid Mytnik, Edwin Perkins, Jie Xiong), five of whom were to be found hard at work at the workshop. Links between the workshop and the other activities (a mini-course, the conference Seminar on Stochastic Processes 1999) are discussed below.

Symposium on Numerical Stochastics  
in Finance  
April 19, 1999

**Organizing Committee:** T. Lyons (Imperial College)  
and T. Salisbury (York University).

**Speakers:**

P. Boyle (University of Waterloo)  
P. L’Ecuyer (Université de Montréal)  
D. Leisen (Stanford University)  
P. Protter (Purdue University)

Workshop on Numerical Methods  
and Stochastics  
April 20-23 1999

**Organizing Committee:** T. Lyons (Imperial College)  
and T. Salisbury (York University).

**Speakers:**

D. Crisan (University of Cambridge)  
P. Del Moral (Université Paul Sabatier)  
J. Gaines (University of Edinburgh)  
A. Guionnet (Université du Paris Sud)  
T. J. Lyons (Imperial College, London)  
L. Miclo (Université de Toulouse)  
P. Protter (Purdue University)  
J. B. Walsh (University of British Columbia)  
F. Viens (University of North Texas)

The April workshop Numerical Methods and Stochastics attempted to survey the use of numerical techniques in stochastic analysis, and to throw light on the directions research in this fields should take over the next few years. As a result, the workshop participants heard a mix of survey talks and research reports. Several talks dealt with numerical SDEs (Jessica Gaines, Terry Lyons - the talks being tied to his module in the finance course and Philip Protter’s). Another group of talks (Dan Crisan, Alice Guionnet, Laurent Miclo, and Pierre Del Moral) focused on particle system methods for getting approximations to analytic problems, including the filtering problem and the Feynman-Kac formula. To combine mathematical expertise of the participants with practical applications, the four-day workshop was held in conjunction with a one-day symposium on Numerical Stochastics in Finance. The symposium saw experts in mathematical finance (Phelim Boyle, Deitmar Leisen), Monte Carlo methods (Pierre L’Ecuyer) and stochastic analysis (Philip Protter) survey the use of various mathematical techniques in modern finance, in the hope that the interaction between workshop and symposium participants would stimulate research in both fields. The symposium ended with Terry Lyons and other speakers in a panel discussion of directions for future research. As should be apparent, the week’s activities had close links to both winter courses, to the finance workshop, and to both the Monte Carlo course and workshop.

NATO Advanced Study Institute on  
Mathematical Problems Arising from Biology  
June 14-24, 1999

**Organizing Committee:** R. Durrett (Cornell University) and C. Neuhauser (University of Minnesota).

**Program Committee:** D. Dawson (Fields Institute), O. Diekmann (University of Utrecht), R. Durrett (Cornell University), S. Levin (Princeton University) and C. Neuhauser (University of Minnesota).

**Speakers:**

O. Diekmann (University of Utrecht)  
P. Donnelly (Oxford University)  
J. Felsenstein (University of Washington)  
B. Golding (McMaster University)  
B. Grenfell (Cambridge University)  
A. Greven (University of Erlangen)  
R. Griffiths (University of Oxford)  
A. Hastings (University of California, Davis)  
R. Hudson (University of Chicago)  
N. Kaplan (National Institute of Environmental Health Sciences, Research Triangle Park)  
S. Levin (Princeton University)  
H. Metz (Leiden University)  
D. Mollison (Heriott-Watt University)  
S. Pacala (Princeton University)  
D. Rand (University of Warwick)  
D. Sankoff (Centre de recherches Mathématiques, Université de Montréal)  
S. Tavaré (University of Southern California)  
A. von Haeseler (Max-Planck-Institut für evolutionäre Anthropologie)

The final event of the program was the NATO Advanced Studies Institute on Mathematical Problems arising from Biology, which ran for ten days. The first week dealt with mathematical models in ecology, while the second week focused on mathematical models in population genetics. Each week featured eighteen talks and a poster session. Nearly 150 people participated, most of whom were students and postdoctoral fellows who were supported during the meeting by NATO, the National Science Foundation, or the Fields Institute. The speakers were distinguished biologists and mathematicians, who surveyed their field and brought the audience to the frontier of current research. During the ecology week, several talks addressed dynamical-systems models of competition between populations, or the detailed modeling of epidemics. One particularly excit-

ing talk was Steve Pacala's description of a large collaborative model of global carbon storage, which builds up to realistic predictions on the scale of the planet, from many detailed models of purely local processes. During the genetics week, participants heard repeatedly about advances in reconstruction of evolutionary or genealogical trees, many of which involved the process known as Kingman's coalescent. Peter Donnelly, Joseph Felsenstein, and Simon Tavaré all gave lucid descriptions of this circle of ideas. Not only did the presence of the coalescent link the NATO Advanced Studies Institute to the workshop on measure-valued processes, but Peter Donnelly gave a strikingly clear introduction to the Dawson-Watanabe and Fleming-Viot superprocesses.



NATO ASI on Problems Arising from Biology  
lecturers in front of the Lash Miller building  
conference site.

L-R: O. Diekmann, H. Metz, S. Pacala, D. Mollison,  
and D. Rand.

## Highlights of the 1999 Winter Term

- The Coxeter Lecture Series, given by Rick Durrett of Cornell University consisted of three lectures, each describing the links between probability and some topic in biology. Many of these links were followed up in detail in the June ASI Mathematical Problems arising from Biology.
- Six further lectures in the Kolmogorov Lecture Series were given. Föllmer's lecture was given in conjunction with the January finance workshop, while Steele and Talagrand spoke on stochastic problems in Combinatorial Optimization, as did Béla Bollobás in the first term. Burgess Davis and Krzysztof Burdzy spoke on topics involving random walks and Brownian motion respectively. Lawrence Shepp spoke on applications of probability to diverse areas, from finance to phase transitions.
- The weekend conference Seminar on Stochastic Processes 1999 was the eighteenth annual conference. As in previous years, emphasis was given to interactions between junior and senior researchers, and roughly half the program was devoted to informal and problem sessions. Many of the topics addressed (e.g. superprocesses, SPDEs, Brownian motion) were of interest to participants at the Interactive Measure-Valued Processes workshop, held the week before. Many participants stayed for the entire two-week period.
- Two nine-hour mini-courses, each of which functioned as an introduction to the topic of one of the workshops, enabled graduate students and other program participants to take full advantage of the workshop presentations. Ed Perkins (University of British Columbia) spoke on Branching Measure Valued Processes and Interactions. Fred Hoppe (McMaster University) spoke on Probabilistic Models in Population Genetics, which served as an introduction to the genetics week of the NATO ASI on biology.
- There were 28 lectures given as part of the weekly seminar series.

## Kolmogorov Lecture Series

- September 18, 1998  
Harry Kesten (Cornell University)  
“Percolation of arbitrary words in  $\{0,1\}^{\mathbb{N}}$ ”
- October 13, 1998  
Béla Bollobás (University of Memphis and Cambridge University)  
“Colourings and Hereditary Properties of Graphs”
- November 17, 1998  
Charles Newman (Courant Institute for Mathematical Sciences)  
“Stochastic Dynamics at Zero Temperature”
- December 8, 1998  
Geoffrey Grimmett (University of Cambridge)  
“An Epidemic with Removal”
- January 26, 1999  
Hans Föllmer (Humboldt Universität - Berlin)  
“Probabilistic Problems Arising From Finance”
- February 9, 1999  
Burgess Davis (Purdue University)  
“Perturbed and Reinforced Random Walks”
- March 23, 1999  
Krzysztof Burdzy (University of Washington)  
“Hot Bodies”
- April 15, 1999  
Michel Talagrand (Université du Paris VI and Ohio State University)  
“Probability and Spin Glasses”
- May 5, 1999  
J. Michael Steele (University of Pennsylvania)  
“Probability Theory and Combinatorial Optimization”
- June 10, 1999  
Lawrence A. Shepp (Rutgers University)  
“Three Studies in Applied Probability”

**August**

“Strict concavity of the Brownian motion intersection exponent”

Greg Lawler, Duke University

**September 9<sup>th</sup>**

“A Pattern Theorem for Lattice Clusters”

Neal Madras, York University

**September 16<sup>th</sup>**

“Moment asymptotics for the Anderson model”

Wolfgang Koenig, Technische Universität Berlin/York University

**September 23<sup>th</sup>**

“Self-diffusion for Brownian Motions with Local Interaction”

Ilie Grigorescu, McMaster University/The Fields Institute

“Infinite Systems of Diffusions in Population Biology”

Jan Swart, University of Nijmegen

“Ruelle’s probability cascades and an abstract cavity method”

Erwin Bolthausen, University of Zurich

**October 13<sup>th</sup>**

“On a Conjecture of B. Jorgensen and A.D. Wentzell: from Extreme Stable Laws to Tweedie Exponential Dispersion Models”

Vladimir Vinogradov, University of Northern British Columbia

**October 14<sup>th</sup>**

“Large Deviation methods in Risk Theory”

Anders Martin-Lof, Stockholm University

**November 4<sup>th</sup>**

“Random walks in a field of traps: from simple random walk on  $Z^d$  to any Markov chain”

Stanislav Volkov, York University/Fields Institute

“Large deviations for observation and related processes”

George L. O’Brien, York University

**November 18<sup>th</sup>**

“Duality for a stochastic p.d.e. with density dependent branching noise” (Joint work with Roger Tribe)

Siva Athreya, Fields Institute

“The lace expansion and oriented percolation”

Eric Derbez, McMaster University/Fields Institute

**November 25<sup>th</sup>**

“Labyrinths”

Stanislav Volkov, York University/Fields Institute

**December 9<sup>th</sup>**

“Metastability and Droplet Growth”

Frank den Hollander, University of Nijmegen

“Large Time Asymptotics of the Nonlinear Filter”

Rami Atar, York University/Fields Institute

**January 6<sup>th</sup>**

“Conditioning Super Brownian Motion”

Tom Salisbury, York University

**January 19<sup>th</sup>**

“Asymptotic Behavior of Solutions of Parabolic SPDE”

Min Kang, York University/Fields Institute

**January 20<sup>th</sup>**

“Liouville property and a conjecture of de Giorgi”

Martin Barlow, University of British Columbia

“Generalizing the Martingale Central Limit Theorem”

Dean Slonowsky, Fields Institute

**February 2<sup>nd</sup>**

“Graph Colouring with the Probabilistic Method”

Michael Molloy, University of Toronto

**February 10<sup>th</sup>**

“A Microscopic Model for Porous Medium Equation”

Shui Feng, McMaster University

**February 17<sup>th</sup>**

“Diffusions and heat kernel analysis on an infinite dimensional group”

Masha Gordina, McMaster University

**February 17<sup>th</sup>**

“Steiner distances in random trees”

Amram Meir, York University

**February 24<sup>th</sup>**

“Trapping and saturation in a random media”

Alejandro F. Ramírez, École Polytechnique Fédérale de Lausanne

“Vertex-Reinforced Random Walks: What’s New?”

Stanislav Volkov, York University/Fields Institute

**March 3<sup>rd</sup>**

“Some results for long range percolation and maniscala models”

Mikhail Menchikov, Moscow State University

“Skew Convolution Semigroups and Immigration Processes”

Zenghu Li, Beijing Normal University

**March 17<sup>th</sup>**

“Vertex Reinforced Random Walks: the techniques”

Stanislav Volkov, York University/Fields Institute

**March 24<sup>th</sup>**

“How does the Vervaat process really behave?”

Ricardas Zitikis, Carleton University

“An Introduction to Set-Indexed Strong Submartingales”

Dean Slonowsky, Fields Institute

**March 31<sup>st</sup>**

“On the long-term behaviour of superprocesses with a general branching mechanism”

Yongjin Wang, Nankai University

“Elements of free probability”

Alexandru Nica, University of Waterloo

**April 7<sup>th</sup>**

“p-variation, integration and stock price modeling”

Rimas Norvaiša, Institute of Mathematics and Informatics, Lithuania

“Random spanning trees of Cayley graphs and compactifications of groups”

Steven Evans, Department of Statistics, University of California, Berkeley

**April 14<sup>th</sup>**

“Asymptotic properties of integral functionals of geometric stochastic processes”

Mikolos Csorgo, Carleton University

“Forward and backward integrals revisited”

Terry Lyons, Imperial College

**April 28<sup>th</sup>**

“Optimal approximation of stochastic differential equations by adaptive step-size control”

Norbert Hofmann, University of Erlangen

**May 5<sup>th</sup>**

“Layout problems on random geometric graphs”

Mathew Penrose, University of Durham

**May 13<sup>th</sup>**

“Level sets of additive Levy processes”

Davar Khoshnevisan, University of Utah

**May 19<sup>th</sup>**

“Quasi-potential of the Fleming-Viot process with neutral mutation and selection”

Kenji Handa, Saga University

**May 26<sup>th</sup>**

“Slice sampler Markov chains”

Jeffrey S. Rosenthal, University of Toronto

**June 2<sup>nd</sup>**

“Relaxation to equilibrium for interacting random walks”

Jeremy Quastel, University of Toronto

**June 9<sup>th</sup>**

“State Dependent Multitype Spatial Branching”

Don Dawson, Fields Institute

# CRM-FIELDS PRIZE

The Centre de recherches mathématiques (CRM) and the Fields Institute for Research in Mathematical Sciences presents this joint prize in recognition of exceptional achievement in the mathematical sciences. A sum of \$5,000 is awarded and the recipients present a lecture at the CRM and the Fields Institute. Previous recipients were Professor H.S.M. (Donald) Coxeter, Professor George Elliott and Professor James Arthur.



## 1999 Recipient

The 1999 winner of the CRM/Fields Prize is **Dr. Stephen Cook** whose principal research area is computational complexity, with excursions into programming language semantics, parallel computation, and especially the interaction between logic and complexity theory. He has authored over 50 research papers, including his famous 1971 paper “The Complexity of Theorem Proving Procedures” which introduced the theory of *NP* completeness. Dr. Cook was the 1982 recipient of the Turing award, and was awarded a Steacie Fellowship in 1977 and a Killam Research Fellowship in 1982. He received computer science teaching awards in 1989 and 1995. He is a fellow of the Royal Society of Canada, and was elected to membership in the National Academy of Sciences (United States), and the American Academy of Arts and Sciences. Eighteen students have completed their PhD degrees under his supervision, and many of them now have prominent academic careers of their own. Dr. Cook will lecture on his research in fall 1999 at the Institute.

Born in Buffalo, New York, he received his B.Sc. degree from the University of Michigan in 1961, and his SM and PhD degrees from Harvard University in 1962 and 1966 respectively. From 1966 to 1970 he was an Assistant Professor at the University of California, Berkeley. He joined the faculty at the University of Toronto in 1970 as an Associate Professor, and was promoted to Professor in 1975 and University Professor in 1985.

## 1998 Recipient

**Dr. Robert Moody** of the University of Alberta was the recipient of the 1998 CRM/Fields Institute Prize for his research in Aperiodic Order, in which he explores quasi-crystal formations. His discovery, independently from and simultaneously with V. G. Kac, of an enormous new class of infinite dimensional Lie Algebras, which are now called Kac-Moody algebras, is considered one of the seminal events in the history of mathematics in the last half of the 20<sup>th</sup> century. In recent years, with various collaborators, Dr. Moody has been studying the mathematical aspects of long-range aperiodic order, especially the quickly emerging area of quasi-crystals.



In September 1999, Dr. Moody lectured at the Fields Institute on the subject of aperiodic order and quasi-crystals. In the natural world we are surrounded by large highly ordered structures that are assembled out of minute entities (atoms). How Nature accomplishes this is largely unknown. The simplest and by far the most common system are the periodic repetition of some basic motive. These are crystals. We now know that there are solid-state materials that are crystallographic in almost every way, including long-range order that rivals in perfection with that found in crystals, which are most definitely not periodic. He examines the mathematics that is being used to model these quasi-crystals, its unexpected origins and the lovely way in which it weaves together various diverse disciplines of mathematics.



# DISTINGUISHED LECTURE SERIES



**Pierre-Gilles de Gennes** of the École Supérieure de Physique et de Chimie Industrielles de la Ville du Paris gave a series of lectures on October 1 and 2, 1998. De Gennes won the 1991 Nobel Prize in Physics for his discovery in the field of superconductivity, polymer physics and magnetism. He presented three dynamic lectures on Branched Polymers and the Ariadne Length, Sand Dunes: How They Form, How They Move, and From Rice to Snow: Some Problems of Granular Matter. One of his greatest strengths is to offer simplified views of complex truths. De Gennes has spent the past several years visiting high schools in France in order to promote revolutionary ideas concerning a more practical and concrete approach to science education. The public lecture on sand dunes was aimed at advanced high school students and from all accounts it was greatly enjoyed by 200 participants.

# COXETER LECTURE SERIES

**Richard Durrett** of Cornell University gave three lectures on May 11 and 12, 1999. The first two lectures were of a more general nature while the third lecture was aimed at the participants of the Probability and Its Applications thematic program.

In the first lecture Durrett spoke on DNA Repeat Sequences. Repeats of short patterns such as CACACA... appear in our DNA at a frequency far greater than if they were due to chance. These repeats have a high mutation rate compared to nucleotide substitutions, so they are useful for locating genes and for understanding population structure on the scale of thousands of years. In this talk, Durrett described a simple model of the evolution of these repeat sequences and he fit this model to DNA sequence data from yeast, fruit flies, mice, and humans.

The second lecture was on Stochastic Spatial Model. In many situations in biology it is useful to consider a model that represents space as a grid of sites, each of which can be in one of a finite number of states and changes at a rate that depends on the state of finitely many neighbours. Durrett and Levin proposed in 1994 that the behavior of these systems can be inferred by looking at the associated “mean field” ODE that is obtained by pretending that all sites are always independent. Durrett described the answers that resulted for a number of systems of interest in biology and illustrated the results with computer simulations.



In the last lecture Durrett talked on the Scaling Limits of Particle Systems. It has long been known that scaling limits of critical branching random walks lead to an interesting measure valued process, now called super-Brownian motion. He described recent results, which show that in two or more dimensions super-Brownian motion is the limit of rescaled contact processes and voter models. To get more interesting limits in  $d=2$  or  $3$ , one can (we think) take multitype contact processes like the colicin systems of Durrett and Levin (1997) and let the interaction parameters between species get large at the right rate to get convergence to models that generalize the interacting super-Brownian motions constructed by Evans and Perkins (1998). Some theorems and simulations were shown in support of this.

# The Fields Institute List of Visitors in 1998-99

Members who were here for longer than two weeks.

Alwis, Pradeep	<i>Fields Institute</i>	Hochberg, Kenneth J.	<i>Bar Ilan University</i>
Atar, Rami	<i>York University</i>	Hofmann, Norbert	<i>Universität Erlangen-Nuernburg</i>
Athreya, Siva R.	<i>Fields Institute</i>	Hong, Zengxin	<i>York University</i>
Banerjee, Pradeep	<i>University of New Brunswick</i>	Hoppe, Fred M.	<i>McMaster University</i>
Barlow, Martin	<i>University of British Columbia</i>	Huang, Fuping	<i>University of Guelph</i>
Biskup, Marek	<i>University of Nijmegen</i>	Hulays, Hayssam	<i>University of Toronto</i>
Bollobas, Bela	<i>University of Memphis</i>	Iftimie, Radu	<i>University of Toronto</i>
Bolthausen, Erwin	<i>University of Zurich</i>	Ivanescu, Cristian	<i>University of Toronto</i>
Brewster, Darron	<i>University of Toronto</i>	Jackson, Ken	<i>University of Toronto</i>
Brooks, Bernard	<i>University of Guelph</i>	Jain, Sonia	<i>University of Toronto</i>
Bucur-Drugan, Alexandru	<i>York University</i>	Jiang, Qingshan	<i>Fields Institute</i>
Burdzy, Krzysztof	<i>University of Washington</i>	Jiang, Xinhui	<i>Fields Institute</i>
Cao, Yongqiang	<i>York University</i>	Kang, Min J.	<i>York University</i>
Chen, Bingshu	<i>York University</i>	Kerr, David	<i>University of Toronto</i>
Chen, Long	<i>University of Toronto</i>	Kersting, Goetz	<i>Universität Frankfurt</i>
Choo, Kiam	<i>University of Toronto</i>	Kesten, Harry	<i>Cornell University</i>
Clement, Philippe	<i>University of Technology at Delft</i>	Khoshnevisan, Davar	<i>University of Utah</i>
Coward, Kristofer	<i>University of Toronto</i>	Kim, Jin Gyo	<i>University of Toronto</i>
Cullen, Christopher	<i>Stone and Webster Canada</i>	Kim, Peter	<i>University of Guelph</i>
Davis, Burgess	<i>Purdue University</i>	Klenke, Achim	<i>Universität Erlangen-Nuernburg</i>
de Gennes, Pierre-Gilles	<i>École Supérieure de Physique et de Chimie Industrielles</i>	Koenig, Wolfgang	<i>York University</i>
Dean, Andrew	<i>University of Toronto</i>	Koh, Daniel L. C.	<i>University of Toronto</i>
Delmas, Jean-Francois	<i>ENPC-CERMICS</i>	Kurtz, Thomas G.	<i>University of Wisconsin at Madison</i>
den Hollander, Frank	<i>University of Nijmegen</i>	Lawler, Gregory F.	<i>Duke University</i>
Derbez, Eric	<i>McMaster University</i>	Lawniczak, Anna	<i>University of Guelph</i>
Durrett, Rick	<i>Cornell University</i>	Li, Rongcai	<i>University of Toronto</i>
Elliott, George	<i>Fields Institute</i>	Li, Zeng-Hu	<i>Beijing Normal University</i>
Elliott, Robert J.	<i>University of Alberta</i>	Lu, Steven	<i>University of Waterloo</i>
Erljman, Juliana	<i>Fields Institute</i>	Lyons, Terry	<i>Imperial College of Science, Technology and Medicine</i>
Evans, Steven N.	<i>University of California, Berkeley</i>	Madras, Neal	<i>York University</i>
Feng, Dingan	<i>York University</i>	Martin-Lof, Anders	<i>Stockholm University</i>
Feng, Shui	<i>McMaster University</i>	McDonald, David R.	<i>University of Ottawa</i>
Fleischmann, Klaus	<i>Weierstrass Institute for Applied Analysis und Stochastics</i>	Menchikov, Mikhail	<i>Universidade de Sao Paulo</i>
Föllmer, Hans	<i>Humboldt-Universität zu Berlin</i>	Miegom, Peter	<i>Fields Institute</i>
Friis, Peter	<i>University of Toronto</i>	Miles, Stanley	<i>York University</i>
Fuks, Henryk	<i>University of Illinois at Chicago</i>	Mohammadalikhani, Ramin	<i>University of Toronto</i>
Fulman, Igor	<i>University of Copenhagen</i>	Montgomery, Neil	<i>University of Toronto</i>
Gärtner, Juergen	<i>Technische Universität Berlin</i>	Mueller, Carl	<i>University of Rochester</i>
Gao, Chris	<i>University of Toronto</i>	Mygind, Jesper	<i>Aarhus University</i>
Geiger, Jochen	<i>Universität Frankfurt</i>	Newman, Charles M.	<i>New York University</i>
George, Chris	<i>University of Toronto</i>	Nica, Alexandru	<i>University of Waterloo</i>
Gorostiza, Luis G.	<i>Centro de Investigacion y de Estudios Avanzados</i>	Nielsen, Steven	<i>University of Toronto</i>
Greven, Andreas	<i>Universität Erlangen</i>	Norvaisa, Rimas	<i>Institute of Mathematics and Informatics</i>
Grigorescu, Ilie A.	<i>McMaster University</i>	O'Brien, George	<i>York University</i>
Grimmett, Geoffrey	<i>University of Cambridge</i>	Panahi, Mehran	<i>University of Saskatchewan</i>
Guimond, Tim	<i>University of Toronto</i>	Pandey, Jagdish	<i>Carleton University</i>
Halevy, Itamar	<i>University of Toronto</i>	Peng, Qiu Liang (Alan)	<i>University of Toronto</i>
Handa, Kenji	<i>Saga University</i>	Penrose, Mathew	<i>University of Durham</i>
Hara, Takashi	<i>Tokyo Institute of Technology</i>	Perkins, Edwin	<i>University of British Columbia</i>
Harmantzis, Fotios	<i>University of Toronto</i>	Pivato, Marcus	<i>University of Toronto</i>
Harvey, Michael	<i>University of Toronto</i>	Pollanen, Marco	<i>University of Toronto</i>
Hashemi, Seyed Naser	<i>University of Waterloo</i>	Pouliot, William	<i>Carleton University</i>
		Pressman, Irwin	<i>Carleton University</i>

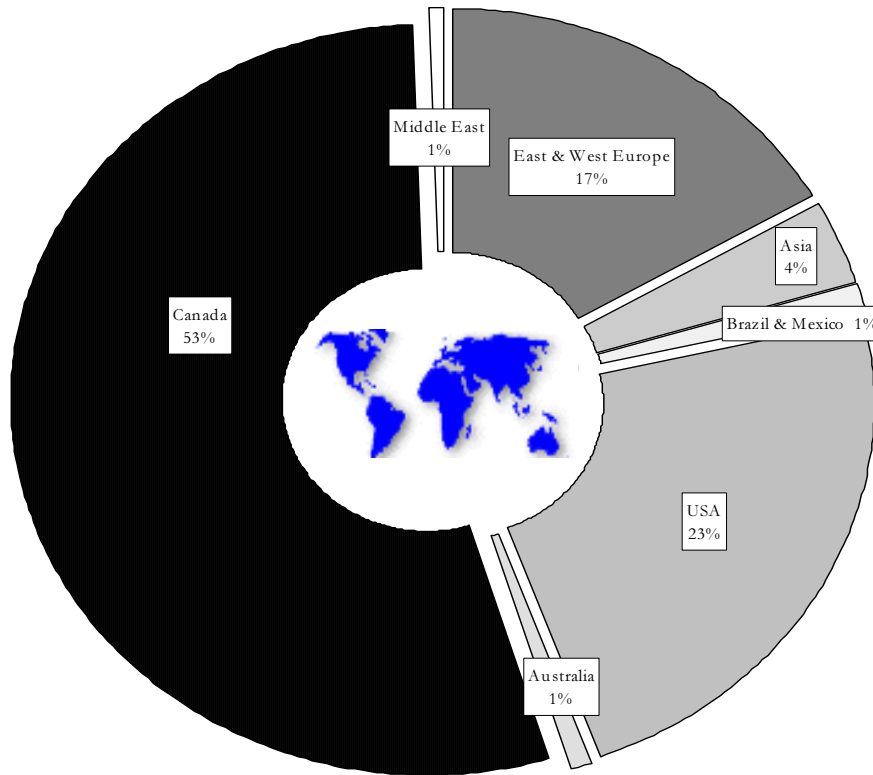
Quastel, Jeremy  
 Ramirez, Alejandro  
 Ravenel, Douglas C.  
 Razak, Shaloub  
 Rolls, David  
 Rosenthal, Jeffrey  
 Ruggiero, Antonio  
 Rusu, Daniele  
 Rybnikov, Konstantin

*University of Toronto*  
*École Polytechnique Federale de Lausanne (EPFL)*  
*University of Rochester*  
*University of Toronto*  
*Queen's University*  
*University of Toronto*  
*University of Toronto*  
*University of Guelph*  
*Queen's University*

Tilahun, Gelila  
 Toms, Andrew  
 Tribe, Roger  
 Turner, Stephen  
 van der Hofstad, Remco  
 van Rensburg, E. J. Janse  
 Vaz, Anthony  
 Vinogradov, Vladimir  
 Volkov, Stanislav

*University of Toronto*  
*University of Toronto*  
*University of Warwick*  
*Cambridge University*  
*Delft University of Technology*  
*York University*  
*McMaster University*  
*University of Northern British Columbia*  
*Columbia*  
*York University*

## Visitors from around the World

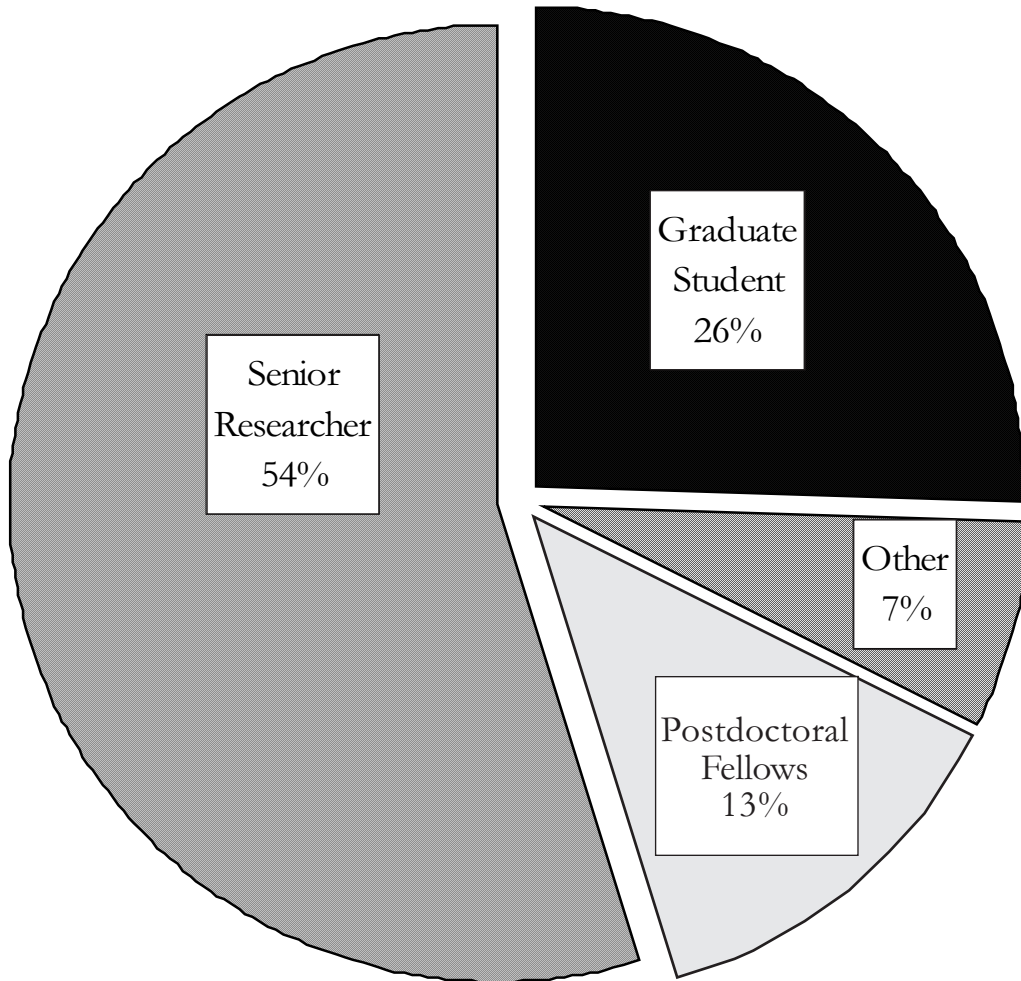


Sabbaye Moghaddam, Maria *University of Toronto*  
 Salisbury, Tom *York University*  
 Salopek, Donna Mary *York University*  
 Samarakoon, D. M. Mahinda *University of Toronto*  
 Saunders, David *University of Toronto*  
 Shazhad, Nadeem *Islamia University*  
 Shepp, Lawrence A. *Rutgers University*  
 Skoulakis, Georgios *University of North Carolina - Chapel Hill*  
 Slade, Gordon *McMaster University*  
 Slonowsky, Dean *Fields Institute*  
 Spijavca, Ruxandra *University of Toronto*  
 Srinivasan, Raj *University of Saskatchewan*  
 Steele, J. Michael *Wharton School of Business*  
 Stevens, Irina *University of Toronto*  
 Swart, Jan *Nijmegen University*  
 Talagrand, Michel *Université du Paris VI*

Vrontos, Spyros  
 Vukojevic, Branko  
 Wakolbinger, Anton  
 Wang, Yongjin  
 Warlow, Scott  
 Winter, Anita  
 Wong, Augustine  
 Wong, Dennis  
 Yang, John Y.  
 Yanxia, Ren  
 You, Soonok  
 Yuan, George  
 Yuan, Xiaobin  
 Zaehle, Iljana  
 Zheng, Zhongrong  
 Zurkowski, Victor Daniel

*Athens University of Economics and Business*  
*Proseed Management Inc.*  
*Universität Frankfurt*  
*Nankai University*  
*York University*  
*Universität Erlangen-Nuernberg*  
*York University*  
*Scotia Capital Markets*  
*RiskLab, University of Toronto*  
*Tsinghua University*  
*York University*  
*University of Queensland*  
*York University*  
*Universität Erlangen*  
*York University*  
*University of Toronto*

# Visitors at the Institute



The total number of visitors to the Fields Institute in the 1998-99 year was 1,126.

### Training Highly Qualified Personnel

The percentage of young researchers was high. Almost 40 percent of the total participants were graduate students and postdoctoral fellows.

# GENERAL SCIENTIFIC ACTIVITIES

## Senior Distinguished Member

Professor George A. Elliott, winner of this year's Synge prize for his outstanding research in operator algebras, was appointed Senior Distinguished Member at the Fields Institute for a second term – 1999-2002.

The Synge Award committee cited Professor Elliott as a mathematician of international reputation and one of the leading experts in the field of operator algebras. He has obtained many substantial results, covering almost every aspect of the field. In particular, his remarkable work on derivations, approximately finite-dimensional algebras,  $C^*$ -algebra K-theory, non-commutative tori, and Schrödinger operators has opened up new dimensions in recent research. And the classification program on which he is now embarked may well prove to have even greater significance.

In the last six years, Professor Elliott has supervised over forty postdoctoral fellows – for periods varying from three months to three years, with the average period being slightly more than one year. Along with receiving the John L. Synge Award in 1999, he has received the following awards: the Jeffery-Williams Lectureship of the Canadian Mathematical Society in 1998, the CRM/Fields Institute Prize in 1996, a Killam Research Fellowship from the Canada Council for the Arts from 1996 to 1998, a Connaught Transformative Research Grant from the University of Toronto from 1995 to 1998, and an NSERC Collaborative Project Grant from 1994 to 1997. He was honoured with an invitation to address the International Congress of Mathematicians in Zurich, Switzerland in 1994. He has been Lektor at the University of Copenhagen since 1972, Adjunct Professor at the University of Toronto since 1984, and Honorary Professor at the University of Wales since 1994.



During the last year, Professor Elliott has worked with a group of seven doctoral students and seven postdoctoral fellows, with investigations mainly centering on the classification program for amenable  $C^*$ -algebras.

# Activities at the Fields Institute

## SIAM Annual Meeting and Conference on Discrete Mathematics July 12-15, 1998

The Fields Institute was pleased to support the meeting that was held at the University of Toronto through providing office space for the speakers and computing services and common space for the participants of the SIAM Meeting.

## Annual Meeting for the Society for Mathematical Biology July 13-17, 1998

The organizer of the meeting was Leon Glass of McGill University. The Fields Institute was pleased to provide an ideal locale for the Society's board meeting, annual meeting and poster session.

## The 1<sup>st</sup> Annual Fields Institute Open house February 5, 1999

The objective of our first Open House was to introduce students to the opportunities existing in the mathematical sciences and to present them with the emerging possibilities in research. In partnership with Carleton University, the University of Guelph, McMaster University, the University of Ottawa, Queens University, the University of Toronto, the University of Waterloo, the University of Western Ontario and York University, we presented 125 students with information on graduate studies. Talks on the new opportunities with academic-industrial linkages were given by MITACS project leaders. Applied and pure mathematics researchers gave talks on opportunities in the mathematical sciences. Some of the Institute's postdoctoral fellows provided displays and posters of their current work

## Seminar on Stochastic Processes March 18-20, 1999

**Program Committee:** E. Cinlar (Princeton University), S. Evans (University of California, Berkeley), G. Lawler (Duke University), T. Salisbury (York University/Fields Institute), M. Sharpe (University of California, San Diego), R. Williams (University of California, San Diego).

The following speakers gave the plenary talks: David Aldous (University of California, Berkeley), Bruce Driver (University of California, San Diego), Hans Föllmer (Humboldt Universität), Leonid Mytnik (Technion) and Wendelin Werner (Université du Paris Sud).

As in previous years, an emphasis was given to the interactions between junior and senior researchers, and roughly half the program was devoted to informal and problem sessions. The Seminar was run in conjunction with the thematic program, Probability and Its Applications.

## Midwest Several Complex Variables Seminar April 9-11, 1999

**Organizing Committee:** J. Bland (University of Toronto), T. Bloom (University of Toronto), I. Graham (University of Toronto) and D. Varolin (University of Michigan).

The meeting consisted of 12 talks in the field of several complex variables. There were 54 people in attendance with graduate students and postdoctoral fellows being almost half of the participants. The long breaks between many of the talks, provided ample opportunity for informal discussions and networking between researchers in the field.

Finnar Larusson (University of Western Ontario) gave a talk on a construction of Riemann surfaces, Richard Hind (University of Michigan) discussed Grauert tubes, Marius Dabija (University of Michigan) discussed dy-

namics on so-called projective bundles and Laszlo Lempert (Purdue University) discussed Dolbeault and Sheaf Cohomology in complex Banach spaces. Greg Buzzard (Cornell University) constructed dominating maps into complex tori. Lei Ni (Purdue University) spoke about estimating small eigenvalues of the Laplacian on compact Kahler manifolds with negative Ricci curvature. John Eric Fornaess (University of Michigan) spoke on the classical subject of  $d$ -bar estimates of Holder-type for convex domains of finite type. Charles Epstein (University of Pennsylvania) presented joint work with G. Henkin addressing the issues surrounding CR embeddable compact manifolds. Eric Schippers (University of Toronto) talked on estimating geometric numerical invariants associated to univalent functions on the unit disc. Jean-Pierre Rosay (University of Wisconsin) spoke on strong boundary values. Sergei Ivashkovich (Université de Lille) presented extensions or holomorphic functions from neighbourhoods of (real) surfaces to large subsets of compact complex surfaces. Yum-Tong Siu (Harvard University) spoke on the nonexistence of smooth Levi-flat hypersurface in complex projective space of dimension  $> 2$ .

## Ontario Topology Seminar

April 30 - May 1, 1999

**Organizer:** Paul Selick (University of Toronto).

The 43rd Semi-annual Ontario Topology Seminar was held at the Fields Institute. There were six invited lectures on recently completed works or works in progress. The topics ranged from the areas of algebraic and geometric topology, symplectic geometry, and representation theory. Don Stanley (Berlin) talked on Lusternik-Schnirrelmann Category. Igor Belgradek (McMaster University) talked on Group Actions. Boris Khesin (University of Toronto) described his new Polar Homology Theory for complex varieties. Paul Selick (University of Toronto) talked on the applications of Lie Modules to Representation Theory. François Lalonde (Université du Québec à Montréal) talked on the collapsing of the Serre Spectral Sequence in Symplectic Fibrations and

Mike Mandell (Massachusetts Institute of Technology) discussed Cochain Multiplications.

The participants came from Ontario universities, Berlin, Quebec and Massachusetts.

## Conference on the Mathematics of Public-Key Cryptography

June 12-17, 1999

**Organizing Committee:** Andrew Odlyzko (AT&T, Florham Park), Gary Walsh (Communications Security Establishment/University of Ottawa) and Hugh Williams (University of Manitoba).

The lectures at this conference primarily dealt with implementation and security issues, which pertain to a facet of Information Security commonly referred to as Public-Key Cryptography. The security provided by these systems relies on the computational difficulty of certain mathematical problems, such as integer factorization, and the computation of discrete logarithms in finite abelian groups.

The talks given at this conference were at the highest scientific level, and were extremely well attended by the participants, as commonly mentioned by many throughout the conference. Some of the more recent developments discussed during these lectures included the recent factorization of the RSA 140-digit challenge number, which represents a new milestone on this problem, a general subexponential-time algorithm for the computation of discrete logarithms in the Jacobian of a hyperelliptic curve, and the infeasibility of the “Xedni-Calculus” attack on the elliptic curve discrete logarithm problem. These results represent the leading edge in research in computational number theory as it applies to cryptography. Some notable discussions included the recent possibility of a general parallel algorithm for solving large sparse systems of linear equations. It is widely believed that this problem is the main bottleneck in the ability to factor large numbers. Consequently, such a development would have enormous impact on the security of the RSA cryptosystem, which is currently be-

ing used in just about every computing facility in the world.

The conference was attended by over 130 people, many of them young mathematicians, who would not have been able to attend without the funding from the Fields Institute. These graduate students and postdoctoral fellows were very much involved in the conference, with some giving lectures (Mark Bauer, Doug Kuhlman, Julia Chen, Andreas Enge, Andreas Stein, and Edlyn Teske). As opposed to a conference of “experts only”, it was refreshing to see so many young, enthusiastic mathematicians involved. From a research point of view, it is crucial to the subject area to bring these individuals into the fold.

Finally, the Fields Institute organized this conference in collaboration with The Communications Security Establishment, Certicom Corporation, Entrust Technologies, and RSA Data Security. Thus, it was a collective effort of academia, government, and industry; perhaps the first of its kind.



Public-Key Cryptography Organizing Committee and Sponsors  
L-R: Don Dawson, Hugh Williams, John Selridge, Ethel Rathbun,  
Gary Walsh, and Carl Pomerance.

## General Scientific Activities Across Canada

**AU** = Event held at an Affiliate University

**PSU** = Event held at a Principal Sponsoring University

### International Conference on Stochastic Programming August 8-16, 1998

**Organizing Committee:** W. T. Ziemba (Chair), R. Wets, A. Ruszczyński, J. Dupacova, A. King, L. Maclean, M. Queyranne, T. Rockafellar, G. Sick and A. Turner.

The 8<sup>th</sup> International Conference on Stochastic Programming was held on the campus of the University of British Columbia to discuss theory and computations in general settings and applications in many areas.

The Vancouver conference had three parts consisting of a two-day weekend tutorial program, organized by Julia Higle, for students and those new to the field. Eighty-nine participants attended the tutorial. The second part was the main conference, organized by William Ziemba and Roger Wets, held on August 10 to 14, which had fourteen main lectures, invited talks, contributed talks, two panel discussions and a computer display evening. There were 170 participants. The third part was an asset-liability management seminar, organized by William Ziemba and John Mulvey, on August 14 to 16. It was attended by 114 participants.

The conference was funded in part by the Fields Institute, IBM, the Frank Russell Company, Falcon Asset Management in Baltimore, the Math Consulting Group AG in Zug, Switzerland, the Program in Financial Modeling, Faculty of Commerce, University of British Columbia and Algorithmics Incorporated and was part of the PIMS Thematic Summer in Mathematical Economics and Finance.

International Conference on  
Operator Theory and Its Applications  
to Scientific & Industrial Problems  
October 7- 11, 1998

AU

**Organizing Committee:** L. Batten (University of Manitoba), P. Binding (University of Calgary), D. Farenick (University of Regina), M. C. Joshi (IIT, Bombay), W. Pedrycz (University of Alberta), A.G. Ramm (Kansas State University), P. N. Shivakumar (University of Manitoba), A. Shklyar, A. Strauss (Ulyanovski Pedagogical Institute, Russia), I. Taqi (University of Kuwait) and H. Williams (University of Manitoba).

The Conference was held at the Institute of Industrial Mathematical Sciences at the University of Manitoba and was commenced by our director, Donald Dawson. The 78 participants were welcomed by Dr. G. Glavin, Associate Vice-President of the University of Manitoba. The scope of the conference was broad and included theoretical aspects of linear and nonlinear operator theory and its applications to numerical analysis, biology, physics and the engineering sciences. Scientific and industrial problems can often be formulated in terms of differential and integral equations. There were many talks on various aspects of the theory and applications of such equations. At the suggestion of the National Science Foundation some sessions addressed the directions of research in the field as well as to formulate some open problems. The Fields Institute in conjunction with the American Mathematical Society will publish the proceedings of the conference, which will be edited by P. N. Shivakumar, A. G. Ramm and A. Strauss.

There were several mini-symposiums organized by internationally known specialists on biomathematics, on ill-posed problems, on mathematical problems in solid mechanics, on operator evolution equations, on non-standard inverse problems arising in electrodynamics.

Among the participants, were internationally known specialists D. Alpay, Y. Alber, J. Ball, G. Elliott, F. Gesztesy, E. Khruslov, A. Ramm, P. Rejto, F. Rofe-Beketov, B. Silbermann, H. de Snoo, V. Strauss, V. Trenogin, N. Voitovich, N. Young. The participants of the conference came from North and South America, Europe and Asia. There were several junior participants and PhD students. The Fields Institute, the Centre de recherches mathématiques and the National Science Foundation supported the Conference.

Graduate Course on Semi-definite  
Programming and its Applications  
Fall 1998

PSU

**Organizer:** H. Wolkowitz (University of Waterloo).

This was held at the University of Waterloo.

CMS Winter 1998 Meeting  
at Queen's University  
December 13-15, 1998

*Please see Societies page for more details.*

1999 Nerenberg Lecture  
March 17, 1999

AU

**Speaker:** Norman Levitt (Rutgers University)  
"The Ambiguous Situation of Science in  
Contemporary Society"

Norman Levitt of Rutgers University gave the 1999 Nerenberg Lecture from a mathematician's view of problematic developments in the humanities regarding science. The talk was attended by approximately 200 people. A short interview of Prof. Levitt was presented on television news broadcasts and the local press also reported on the event.

The Nerenberg Lecture is aimed at promoting mathematics and related subjects, not only among the general public but also among other non-technical academics. The aim was to exemplify the relevancy of abstract and technical knowledge. This is undertaken by presenting general lectures from mathematicians or scientists who have something authentic to say on big themes to a general audience.

## Discrete and Probabilistic Mathematics Day in Honour of Paul Erdos

April 24, 1999

AU

**Organizers:** Carleton School of Mathematics and Statistics (specifically B. Richter and I. Pressman) and the Laboratory for Research in Statistics and Probability (Administrative matters organized by G. Murray).

Almost 60 people attended from Carleton University, the University of Ottawa, local businesses and government offices, along with one participant from University of Venice, one from the Bulgarian Academy of Sciences, two from the University of Clarkson and one from the University of Massachusetts.

The participants attended talks by Bill Jackson (University of London, UK), Rodney Canfield (University of Georgia), Neal Madras (York University), and Miklos Csorgo (Carleton University) and reminisced on Paul Erdos and his impact on mathematics. The Cultural Attachee from the Embassy of the Republic of Hungary, Norbert Konkoly, attended the morning session and the reception. The Hungarian Embassy partly sponsored the Wine and Cheese reception in the afternoon.

## 27th Canadian Operator Theory and Operator Algebras Symposium

May 20-24, 1999

**Organizer:** G. MacDonald (University of Prince Edward Island).

The Symposium was held at the University of Prince Edward Island. The principal speaker was Professor David Larson of Texas, A&M who gave three lectures with a general theme of Operator Algebras and Wavelets. The invited speakers were David Blecher (University of Houston), Man-Duen Choi (University of Toronto), Ken Davidson (University of Waterloo), George Elliott (University of Toronto), Liming Ge (University of New Hampshire), Don Hadwin (University of New Hampshire), David Handelman (University of Ottawa), Steve Power (University of Lancaster) and Heydar Radjavi (Dalhousie University).

In conjunction with the CRM, PIMS and the Atlantic Association for Research in Mathematics (AARMS), the

Fields Institute was delighted to support the symposium. The symposium once again met its aims of introducing graduate students and recent graduates in Operator Theory to an active community, which helps to maintain Canada's position as one of the leaders in this field.

## 1999 Canadian Mathematical Society Summer Meeting

May 29-June 1, 1999

*Please see Societies page for more details.*

## CRM-AARMS Darboux-Backlund Conference

June 2-4, 1999

AU

**Organizers:** A. Coley (Dalhousie University), R. Milson (Dalhousie University) and P. Winternitz (Université de Montréal).

The pre-conference was held at Dalhousie University. Valery Gromak (BSU), Decio Levi (Rome), Robert Milson (Dalhousie), Peter J. Olver (Minnesota), Colin Rogers (New South Wales) and Wolfgang Schief (New South Wales) gave the introductory lectures on modern techniques in the theory of DE's preceding the CRM-AARMS Darboux-Backlund conference. Fields in conjunction with CRM, PIMS and AARMS partly funded the conference.

## Statistical Society of Canada Annual Meeting

June 6-9, 1999

*Please see Societies page for more details.*

## Canadian Operational Research Society - CORS-SCRO '99

June 7-9, 1999

**Organizing Committee:** R. J. Caron (University of Windsor), D. Stanford (University of Western Ontario), R. Lashkari (University of Windsor), P. Brill (University of Windsor), Y. Aneja (University of Windsor), M. Hlynka (University of Windsor), W. Caron, S. Drekcic

(University of Western Ontario) and T. Traynor (University of Windsor)

The Annual Meeting of the Canadian Operational Research Society brought researchers from academia, government and business from across the country to Windsor, Ontario. Special effort was made to attract students to the conference and it was successful as a total of 48 students attended. The conference themes were Applied Probability and Queues, Mathematical Programming, and Decision Analysis as it is related to manufacturing and transportation. These were marked by the following plenary lectures:

- Harvey J. Greenberg (University of Colorado at Denver) “Development of an Intelligent Mathematical Programming System: Past Present and Future,”
- John Mann, (Daimler-Chrysler Canada,) “Research and Development at Daimler-Chrysler Canada Incorporated,”
- Carl M. Harris (George Mason University, Fairfax, VA) “Coxian And Pareto Queues, with Special Application to Internet Traffic Engineering,” and
- Gilbert Laporte (Université de Montréal, Montréal) “Recent Algorithmic Advances for the Vehicle Routing Problem”.

Themes introduced by the plenary speakers, as well as Health Care, were further developed by our ten tutorial speakers. The conference had strong representation from both Canada and the US in queuing theorists and served the purpose of providing first introductions between some of the younger researchers in Canada and the leading specialists from both sides of the border. In addition, representation from organizations such as Ford, Daimler-Chrysler, Dofasco, and the Department of National Defense introduced challenging new problems to academic researchers.

The success of the conference was illustrated by the animated conversations taking place at all tables during the closing banquet and the high attendance of all talks right up to the last session.

## 1999 Canadian Applied and Industrial Mathematics Society Annual Meeting

June 11-13, 1999

*Please see Societies page for more details.*

## High Performance Computing Symposium 1999

June 13-16, 1999

AU

**Organizing Committee:** A. Pollard (Queen’s University): Conference Chair, J. Fugere (Royal Military College), D. Mewhort (Queen’s University), D. Weaver (Queen’s University), D. Skillicorn (Queen’s University) and L. Moreland.

The conference was held at Queen’s University.

## The 6th Conference of the Canadian Number Theory Association

June 20-24, 1999

AU

**Organizing Committee:** J. Borwein (Simon Fraser), D. Boyd (University of British Columbia), C. David (Concordia University), R. Murty (Queen’s University), P. N. Shivakumar (University of Manitoba), C. Stewart (University of Waterloo), H. Williams (University of Manitoba) and S. Henderson.

The Canadian Number Theory Association (CNTA) was founded in 1987 at the International Number Theory Conference at Laval University. The purpose of the CNTA is to enhance and promote learning and research in Number Theory, an area where Canada already has a great deal of strength.

The conference was held at the University of Manitoba and it focused mainly on combinatorial/computational number theory, analytic number theory, diophantine problems and arithmetic geometry. All of these areas have seen rapid development in recent years, both in Canada and internationally. We selected the invited speakers in accordance with the themes Mahler’s measure and L-functions, computational combinatorial number theory, Diophantine approximation, arithmetic algebraic geometry, and computations and curves.

## Interdisciplinary Activities

In the 1998-99 year, the Institute continued to develop and strengthen interactions with all areas of mathematics, as well as linking business and industry to these interactions. Providing opportunities for networking between junior researchers, senior researchers and industrial partners is an important objective of the Institute.

- The Probability and Its Applications program ran a highly successful workshop on Probability in Finance that was supported in part by Algorithmics Incorporated and Canadian Imperial Bank of Commerce.
- In June the Institute held the Conference on the Mathematics of Public-Key Cryptography that brought together academia, industry and government.
- In conjunction with the Department of Statistics at the University of Toronto we began a new seminar series called the Applications of Statistical Science Seminar Series that brought together researchers and practitioners from the medical, physical, engineering, mathematical, and social sciences.
- Our Financial Mathematics Seminar Series was once again highly successful with monthly attendance ranging from 80 to 100 people and coming from both academic and financial business backgrounds.
- The Industrial Mathematics Seminar Series which focused on Inverse problems, Cryptography and Artificial Intelligence and the Deep Blue.

## Applications of Statistical Science Seminar Series

### **December 17, 1998**

Rob Tibshirani (Stanford University),  
“Additive Logistic Regression: a Statistical View of Boosting”.

### **January 5, 1999**

Stuart Whittington (University of Toronto),  
“Randomly coloured self-avoiding walks”.

### **February 2, 1999**

Shelley Bull (Mount Sinai Hospital & University of Toronto),  
“Statistics and the Genetics of Complex Human Disease”.

### **March 2, 1999**

David Andrews (University of Toronto),  
“The smell of greasepaint, the roar of the computer: 25 years of television network election night forecasting”.

### **April 6, 1999**

Carl Amrhein (University of Toronto),  
“Computational solutions to problems encountered in spatial data analysis”.

### **May 4, 1999**

Yoshua Bengio (Université de Montréal),  
“Estimating and Improving Generalization Error for non-i.i.d Data”.

### **June 1, 1999**

Dan Krewski (University of Ottawa),  
“Statistical Issues in Population Health”.

This series was co-sponsored with the Statistics Department of the University of Toronto.

## Financial Mathematics Seminar Series

### September 30, 1998

John Hull (University of Toronto),  
“Enhancements to the Standard Approaches for Calculating Value at Risk”.

Kenneth Singleton (Stanford University),  
“Specification Analysis of Affine Term Structure Models”.

### October 28, 1998

Peter Ritchken (Case Western Reserve University),  
“Option Pricing Under GARCH Like Processes”.

Vance Lindsay Martin (University of Melbourne),  
“Forecasting Exchange Rate Crises with an Application to the Asian Currency Meltdown”.

### November 25, 1998

Gregory R. Duffee (Federal Reserve Board),  
“Can affine term structure models forecast changes in Treasury yields?”.

Alexander Levin and Alexander Tchernitser (Bank of Montreal),  
“Stochastic Variance Value-at-Risk Model”.

### January 27, 1999

Steven Ross (Massachusetts Institute of Technology),  
“Topics in Finance”.

### February 24, 1999

Sanjiv Das (Harvard University),  
“Jumps in Interest Rate Diffusions: Theoretical Option Pricing and Empirical Models”.

Alain Belanger (Bank of Nova Scotia),  
“A Unifying Credit Model”.

### March 31, 1999

Michael Taksar (State University of New York - Stony Brook),  
“Diffusion Models for Optimal Risk/Dividend Control of a Financial Corporation - An Insurance Company Example”.

Alexandra E. MacKay (University of Toronto),  
“Term Structure Estimation: The Implied Norm Approach Negative Option Prices — A Puzzle or Just Noise?”.

### April 28, 1999

Ronnie Sircar (University of Michigan),  
“Stochastic Volatility and Separation of Scales”.

Jin-Chuan Duan (Hong Kong University of Science & Technology),  
“Option Valuation with Co-Integrated Asset Prices”.

### May 26, 1999

René Garcia (Université de Montréal),  
“Asymmetric Smiles, Leverage Effects and Structural Parameters”.

Eleanor J. Morrison (Portfolio Manager, Powerex),  
“Value at Risk: Application to Electricity”.



Eleanor Morrison discussing her research with seminar participants.

## Industrial Mathematics Seminar Series

### **October 15, 1998**

André Van Schyndel (Nortel Networks Ltd.),  
“Mathematical Successes and Challenges on the Network Edge” .

Henning Rasmussen (University of Western Ontario),  
“Inverse Problems: Formulation and Solution”.

### **February 11, 1999**

Alberto Leon-Garcia (University of Toronto)  
“Virtual Networks and Programmable Network Nodes”.

David R. McDonald (University of Ottawa),  
“Cell Loss Probabilities Using the Oldest-Cell-First Discipline” .

### **March 11, 1999**

Gabriel M. Silberman (IBM Centre for Advanced Studies),  
“Deep Blue: IBM’s Massively Parallel Chess Machine”.

Monty Newborn (McGill University),  
“Some Lessons from Deep Blue”.

### **May 13, 1999**

Doug R. Stinson (University of Waterloo),  
“Distributed Trust Mechanisms in Information Security and Cryptography”.

P. Gary Walsh (Communications Security Establishment and Ottawa University),  
“The Mathematics of Public-Key Cryptography”.

# Cooperation with the Canadian Mathematical Sciences Societies

Part of the Fields Institute's mandate is to support the activities and members of the Canadian mathematical sciences societies.

## Statistical Society of Canada

Annual Meeting  
June 6-9, 1999

The meeting was held at the University of Regina. From all accounts, it was a great success with about 300 participants attending. The program included 43 scientific sessions, of which 25 were invited paper sessions. Of these, the Field's Institute was the official sponsor of a Special Biostatistics Session of the Fields Institute: Environmetrics and Chemometrics. Among the featured speakers were: Rudolf Dutter (Vienna University of Technology), Cliff Spiegelman (Texas A&M University), E. Park (University of Washington); Timothy G. Grsegoire (Yale University), Oliver Schabenberger (Michigan State University) and Ross Leadbetter (University of North Carolina).

The SSC also organized two workshops, one dealing with biostatistics and the other dealing with survey methods, which were held on June 6. The Biostatistics Workshop focused on "Animal Population Estimation" and the speakers were Jim Nichols and Jim Hines, (Patuxent Wildlife Research Centre) and Carl Schwartz, (Simon Fraser University). The Survey Methods Workshop was titled Computer Algebra for Sample Surveys and presented by David Bellhouse and Jamie Stafford of the University of Western Ontario.

## Canadian Mathematical Society

Winter '98 Meeting  
December 13-15, 1998

The meeting was held in Kingston with support from Queen's University. H.S.M. Coxeter gave the public lecture entitled The Descartes Circle Theorem and Fibonacci Numbers. The registration for the meeting soared to almost 300 people; and from all accounts was highly successful. The Fields Institute supported the session on Probability Theory that was organized by M. Csörgo (Carleton University) and attended by many of the postdoctoral fellows who were at the Institute with the Probability thematic program.

As a new initiative the Fields Institute supported some of the Education sessions -- Education II - Teaching Mathematics - Why We Do What We Do in the Classroom and Mathematics on the Internet..

Summer '99 Meeting  
May 28-June 2, 1999

The summer meeting was held at Memorial University in St. John's, Newfoundland. Once again it was a great meeting with over 250 participants. Edward Barbeau gave the public lecture entitled Delicious Mathematics. The Fields Institute supported the session on Representation Theory, which was organized by Abraham Broer (Université de Montréal). The speakers included Jon Brundan (Oregon at Eugene), Ranee K. Brylinski (Pennsylvania State), Clifton Cunningham (Massachusetts), Sam R. Evens (Arizona at Tucson), Loek Helminck (North Carolina State), Markus Hunziker

(Brandeis), Alex S. Kleshchev (Oregon at Eugene), Friedrich Knop (Rutgers), V. Lakshmibai (Northeastern), W. Monty McGovern (Seattle), George McNinch (Notre Dame), Fiona Murnaghan (Toronto), Arturo Pianzola (Alberta), David Renard (Poitiers), Yasmine Sanderson (Rutgers), Gordan Savin (Utah) and Eric Sommers (Harvard).

## Canadian Applied and Industrial Mathematics Society

20<sup>th</sup> Annual Meeting  
June 11-13, 1999

**Local Organizing Committee:** M. Fortin (President), M. Beauchamp, J. - J. Gervais, H. Manouzi and R. Pierre.

**Scientific Committee:** M. Fortin (Université Laval), J. Bélair (Université de Montréal), F. Bergeron (Université du Québec à Montréal), J. Clements (Dalhousie University), H. Manouzi (Université Laval), R. Miura (University of British Columbia), B. Moodie (University of Alberta) and B. Simpson (University of Waterloo).

The 20th Annual Meeting of the Canadian Applied and Industrial Mathematics Society/Société Canadienne de mathématiques appliquées et industrielles (CAIMS) was held simultaneously with the Journée des éléments finis at Université Laval, Québec on June 11-13, 1999. The meeting was attended by over 130 participants from Canada, Europe and the United States.

The Keynote speakers were Max Gunzburger, Goetz Alefeld, Odo Diekmann and Martin Golubitsky. There were 12 minisymposia with the following themes: quantum computing, population dynamics, phase transition in materials, mathématiques et physiologie, control problems for non-linear partial differential equations (PDEs), interval arithmetics, bifurcation theory, and numerical methods and simulations for PDEs. One minisymposia was organized in collaboration with the Society for Industrial and Applied Mathematics and another one in collaboration with Gesellschaft für Angewandte Mathematik und Mechanik.

The 1998 CAIMS Doctoral Dissertation Awards (DDA) were presented to Dr. Troy Day of Queen's University and Dr. Jon-Paul Voroney of the University of Guelph. Judgement was based on the originality in the ideas and

techniques, possible applications, and potential impact on science and engineering.

The DDA Committee cited Dr. Day's dissertation as an outstanding piece of modern applied mathematics work that is extremely creative and Dr. Voroney's dissertation as an excellent, comprehensive applied mathematics treatise, which is exceptionally well written. They said, "Dr. Voroney demonstrated that Turing pattern can also exist in an inhomogeneous system. The work is thought provoking and is expected to have many papers along these directions in the coming years. The candidate demonstrated unusual skills of writing and using a nice array of mathematical tools theory of dynamical systems, lattice gas automaton, Maple and C in simulations."

The Fields Institute is pleased with the recognition of Dr. Voroney as it demonstrates the fruitful impact of our scientific activities can have on the education of graduate students. Dr. Voroney was one of the first graduate students to take courses at the Institute. He learned many intricacies of dynamical systems theory and lattice gas automata during the Institute's Dynamical Systems and Bifurcation Theory Program in 1992 to 1993. Dr. Voroney commenced his research work on spatio-temporal dynamics in reactive systems, under the supervision of Professor Lawniczak, one of the program participants and active members of the Fields Institute. His work resulted in B.Sc. thesis in 1994 and a PhD thesis in 1998.

# Mathematics Education

## The Fields Institute Graduate Courses

The seven graduate courses offered at the Institute in conjunction with the thematic program, Probability and Its Applications, provide a significant contribution to the education of graduate students and postdoctoral fellows at Canadian universities. Our future thematic programs will also include graduate courses. Information can be found on the our web-site at [www.fields.utoronto.ca](http://www.fields.utoronto.ca).

### 1998-99 Graduate Courses:

1. Large Deviation Theory: Introduction and Applications,
2. Monte Carlo Methods,
3. Percolation,
4. Brownian Motion, with Applications,
5. Topics in Stochastic Analysis and the Mathematics of Finance,
6. Mini-Course: Branching Measure-Valued Processes and Interactions,
7. Mini-Course: Probabilistic Models in Population Genetics.

## The Fields Institute Mathematics Education Forum

The Fields Institute Mathematics Education Forum continued to bring together leading experts in Mathematics Education, representing all sectors and interests to discuss issues, exchange ideas and make recommendations for change. The Steering Committee of the Forum, elected in the autumn of 1998, consists of Lynda Graham (Sheridan College), Myrna Ingalls (Unionville High School), Mary-Lou Kestell (EQAO), Geoff Roulet (Queen's University), David Zimmer (ITP Nelson) and Bill Langford (Fields Institute).

A particular focus of the Forum this year has been to provide input to the process of secondary school reform, which is now underway in Ontario. In May 1998, the Fields Institute was awarded the contract to write the Ontario Secondary School Curriculum Policy Document for Mathematics. With the successful completion of this contract in December 1998, the Forum looked at the major issues facing mathematics education in Ontario. In March 1999, the Forum established a new working group to study and make recommendations on emerging issues in mathematics education.

## Contract for the Ontario Secondary School Mathematics Curriculum

In the winter of 1998, the Fields Institute submitted a bid in response to the Ministry of Education and Training's (MET) Request for Proposals that would award the contract to write the Ontario Secondary School Curriculum Policy document for mathematics. This bid was submitted in partnership with an outstanding team of mathematics educators from the Mathematics Education Forum and represented the Ontario Association of Mathematics Education (OAME), the Ontario Colleges Mathematics Association (OCMA), the Ontario Mathematics Coordinators Association (OMCA), universities, colleges and the private sector. Our bid was successful, and the contract was awarded in May 1998. The Project Manager was Judy Crompton, previous President of the OAME and 1998 recipient of the Prime Minister's Award for Teaching Excellence. The Curriculum Development Team worked at the Fields Institute throughout the year with the peak activity in the summer months. The contract was successfully completed, on time and within budget in December 1998. It has received high praise from both the MET and teacher groups.

The Curriculum Policy document can be viewed at the Ministry of Education Web-site:  
<http://www.edu.gov.on.ca/eng/document/curricul/secondary/math/mathful.html>



Photo of Judy Crompton (left),  
Leader of the Ontario Secondary School  
Mathematics Curriculum Policy document team.

## Proposal to the MET on Future Needs in Mathematics Education

**D**emographic forecasts indicate that half of the mathematics teachers in Ontario schools will retire within the next 10 years. Emerging technologies and economic forces are changing the way mathematics is being used and taught. The Province's Access to Opportunities Program (ATOP) will increase the demand for mathematics teachers at the secondary and post-secondary levels. The new Ontario curriculum, which was written at the Fields Institute, places an additional need for change in the classroom on teachers. In March 1999, the Forum established an ad hoc committee, consisting of Edward Barbeau (University of Toronto), Donald Dawson, (Fields Institute), John Ip (Toronto Board of Education), John Kezys (Mohawk College), William Langford (Fields Institute), Eric Muller (Brock University), Elizabeth Pattison (Niagara), Pat Rogers (York University Faculty of Education), Geoff Roulet (Queen's University Faculty of Education), and Walter Whiteley (York University). This group gathered information in order to recommend concrete actions that addresses the future crisis in mathematics education.

As a result of the efforts of the group, a proposal was submitted to Deputy Minister Veronica Lacey of the Ministry of Education and Training in May. The proposal, titled Meeting Future Needs for Mathematics Education in Ontario, seeks to offer solutions to avert the looming crisis, and harness the forces of change for the betterment of mathematics education in Ontario. The key strategy of the proposal is to exploit the opportunity presented by the fact that the year 2000 has been declared World Mathematical Year .

# Canada-USA Mathcamp

**T**he Canada-USA Mathcamp is an annual event for mathematically talented high school students, enabling them to discover the beauty and variety of mathematics in the company of outstanding mathematicians and other students from around the world. Last summer from July 5 to August 9, the Canada-USA Mathcamp was co-hosted by the Fields Institute and the University of Toronto, with other sponsors such as Hewlett Packard and Waterloo Maple. The Mathcamp faculty, who included famous mathematicians such as John Conway, Carl Pomerance, Richard Guy, Richard Askey and Kumar Murty, had their offices in the Fields Institute building for the duration of the session.

## High School Mentoring Program

**F**or the past three years, the Fields Institute has hosted a mentoring program for high school students who are highly talented in mathematics. These students meet weekly at the Institute, where Dr. George Elliott and a dedicated team of volunteer mathematicians, many who are postdoctoral fellows at the Institute, coach them.

## Off-site Educational Activities

**D**uring the past year, the Institute has provided support to activities of the OMCA, the OCMA, the Canadian Undergraduate Mathematics Conference and the 1998 MAA Summer Mathfest at Ryerson University. The two sessions on Mathematics Education at the CMS Winter Meeting in Kingston, in December 1998, were funded by the Fields Institute.

At the 26th Annual Meeting of the Ontario Association for Mathematics Education, May 6 to 8, 1999 in Richmond Hill, the 6th Annual Fields Institute Lecture was presented by William Langford, on the topic of Deterministic Chaos.

On June 3 and 4, 1999, Professor John Hubert of Guelph University presented the Fields Institute Lecture on Applied Statistics at the Annual Meeting of the Ontario Colleges Mathematics Association.

Deputy Director Bill Langford is an Advisor to the OISE/UT Impact Math Implementation Network, which was created to implement the new Ontario Grade seven and eight mathematics curriculum, through a "Train the Trainers" model.

The Fields Institute was a sponsor of the Conference on Technology in Mathematics Education at the Secondary and Tertiary Levels, at Brock University on June 3 to 4, 1999.

Dr. Langford gave a plenary lecture at Brock University for the Canadian Mathematics Education Study Group, on Industrial Mathematics for the 21<sup>st</sup> Century.

# COORDINATION WITH CANADIAN INSTITUTES AND ASSOCIATIONS

## Centre de recherches mathématiques & the Pacific Institute for Mathematical Sciences

The Fields Institute works closely with both the Centre de recherches mathématiques (CRM) and the Pacific Institute for Research in Mathematical Sciences (PIMS) to coordinate thematic program activities and to support national workshops and conferences. Many of our upcoming thematic programs are being planned with joint scientific events and sessions. In order to coordinate the joint funding of events across the country a joint scientific review panel, The National Committee of the Mathematical Sciences Research Institutes, has been implemented to evaluate and fund national activities. The three institutes will contribute funding to the program and the panel will be drawn from the scientific panels.

### Jointly Funded Activities

- CRM-Fields prize has been awarded since 1995 in recognition of exceptional research achievement in the mathematical sciences in Canada. Prize recipients receive an award and lecture at both the Centre de recherches mathématiques and the Fields Institute. Prizes have been awarded to H.S.M. Coxeter, George A. Elliott, James G. Arthur, Robert Moody and Stephen Cook.
- The Fields Institute along with the CRM contributed to the financial support of PIMS.
- The International Conference on Stochastic Programming in August 1998 was held at the University of British Columbia and was jointly sponsored with PIMS.
- The International Conference on Operator Theory and Its Applications to Scientific & Industrial Problems in October 1998 was held at the University of Manitoba and was co-sponsored with the CRM.
- The 27th Canadian Operator Theory and Operator Algebras Symposium held at the University of

Prince Edward Island in May 1999 was co-sponsored with CRM and PIMS.

- The pre-conference Workshop on DE's and the CRM-AARMS Darboux-Backlund Conference, held at Dalhousie University in June 1999 was co-sponsored with the AARMS, CRM, and PIMS.
- The 6<sup>th</sup> Conference of the Canadian Number Theory Association held at the University of Manitoba in June 1999 was co-sponsored with CRM.
- The 13th Annual International Symposium on High Performance Computing Systems and Applications held at Queen's University in June 1999 was co-sponsored with CRM.

One of the most significant illustrations of the cooperation between the institutes is the implementation of the Mathematics of Information Technology and Complex Systems (MITACS), a new member of the Networks of Centres of Excellence (NCE). (Please see the MITACS section for full details.)

## Atlantic Association for Research in the Mathematical Sciences

The Fields Institute has been supporting and collaborating with the Atlantic Association for Research in the Mathematical Sciences (AARMS) for several years now. The Institute has supported summer schools and workshops to encourage and further research in all mathematical sciences in the Atlantic region. The Institute supported the 27th Canadian Operator Theory and Operator Algebras Symposium at the University of Prince Edward Island, the pre-conference Workshop on DE's and the CRM-AARMS Darboux-Backlund Conference held at Dalhousie University.

# THE MATHEMATICS OF INFORMATION TECHNOLOGY AND COMPLEX SYSTEMS

The challenge to bring Canada into the forefront of mathematical modeling was the driving force behind the creation of The Mathematics of Information Technology and Complex Systems (MITACS), a new member of the Networks of Centres of Excellence (NCE). MITACS is in a unique position to harness Canadian mathematical power. It provides a large scale systematic program to conduct research, to train highly qualified personnel and to develop partnerships with key businesses in the industrial and health-care sectors.

MITACS is a joint venture of the three Canadian mathematical institutes: the Centre de recherches mathématiques, the Fields Institute for Research in Mathematical Sciences, and the Pacific Institute for the Mathematical Sciences. Following a successful submission to the 1997 federal NCE competition, MITACS was officially launched on October 16, 1998.

The objectives of MITACS, as stated in the Network Agreement are:

1. to enable and encourage the generation of new research ideas and new technologies within a world-class research program,
2. to develop linkages among those research, development and investment communities where mathematics is pertinent; in universities, companies, hospitals and government,
3. to expand the highly qualified resource of individuals skilled in the development and application of mathematical models, and
4. to support the application of research results for the economic and social benefit of Canada.

Project teams include university faculty, research associates, postdoctoral fellows, graduate students and industrial scientists. At this time, a total of 188 university faculty are MITACS Investigators. Networking is key to MITACS activity, among research members on a team and among the projects.

MITACS currently has 21 research projects organized into five themes:

- Biomedical,
- Industrial/Commercial,
- Information Technology,
- Trading/Finance, and
- Manufacturing.

The Fields Institute is currently responsible for seven projects.

## Mathematics of Financial Risk Management

**Leader:** Dr. L. Seco, University of Toronto.

**Members:** P. Boyle (University of Waterloo), M. Crouhy (Canadian Imperial Bank of Commerce), G. Dionne (École des Hautes Études Commerciales), J. Im (Canadian Imperial Bank of Commerce), K. Jackson (University of Toronto), D. McLeish (University of Waterloo), G. Nudelman (Canadian Imperial Bank of Commerce) and E. Prisman (York University).

**Industrial Affiliates:** Algorithmics Incorporated, Canadian Imperial Bank of Commerce, Bank of Nova Scotia and Refco Futures.

**Problem Statement:** Pricing of derivatives, hedging, risk metrics have become standard tools for market risk management and for the creation of many new financial instruments. They have also stimulated a new area of mathematical research activity. This field is rapidly moving to a higher level of sophistication and methodological challenge. For example, one of the important recent developments faced by the banks is the need to quantify credit risk; to have capital requirements based on credit risk and possibly to trade credit risk in the form of credit derivatives. This creates the need to develop a sound basis and methodology for credit derivatives. In view of the lengthy time horizon involved, completely new methodological challenges arise in their evaluation. This example illustrates the type of problem for which the basic research has not

yet resolved the central questions but is one issue which financial institutions expect will emerge within the next year or so.

Portfolio theory has been the central object of study in mathematical finance since the work of Nobel Laureate Markovitz in the 50's. This provides financial firms with investment strategies that archive their risk/reward goals. When approaching portfolio theory from the risk management viewpoint, fundamental differences appear which force us to adopt novel ideas. The basic fact underlying this is that one now needs to deal with the portfolio of whole institutions, for which traditional theories become impractical. The way out of this is through portfolio compression. Roughly speaking, this theory allows one to replace huge portfolios with smaller ones. In practice, it is the particular risk-issue that determines which compression methodology to adopt. The proposed research is an investigation of compression issues in all-contemporary situations.

## Statistical Modeling and Analysis of Complex Traits in Human Populations

**Leader:** S. Bull (University of Toronto).

**Members:** D. Andrews (University of Toronto), M. Corey (Hospital for Sick Children Research Institute/University of Toronto), G. Darlington (Cancer Care Ontario/University of Toronto), M. Escobar (University of Toronto), C. Field (Dalhousie University), P. Hooper (University of Alberta), K. Morgan (Montreal General Hospital Research Institute/McGill University), B. Smith (Dalhousie University) and D. Tritchler (Ontario Cancer Institute/University of Toronto).

**Industrial Affiliates:** Ellipsis Biotherapeutics, Mount Sinai Hospital, Ontario Cancer Institute and Montréal General Hospital.

**Problem Statement:** Complex traits, including disease and disabilities, that vary in human populations are determined by multiple genetic and environmental factors that interact with one another in complicated, often non-linear ways. The nature and complexity of these interactions depend on characteristics of the population as well as characteristics of the individual and the family. With continuing advances in molecular biotechnology and the prospect of a complete reference sequence of the entire human genome in the near future,

biomedical investigators face an explosion in data that is highly dimensional and have complex structure. Appropriate analysis is required to direct scientific energy and resources into feasible and effective medical interventions.

## Modeling and Analysis of Networks of Neurons: Understanding Their Role in Information Processing and Control

**Leader:** S. Campbell (University of Waterloo).

**Members:** M. Hulliger (University of Calgary), W. Langford (University of Guelph), M. Mackey (Centre for Nonlinear Dynamics in Physiology and Medicine), J. Milton (McGill University/University of Chicago), P. van den Driessche (University of Victoria), J. Wu (York University) and X. Zou (Memorial University of Newfoundland).

**Industrial Affiliate:** Generation 5.

**Problem Statement:** The spatio-temporal dynamics of large numbers of neurons in the central nervous system lie at the basis of phenomena such as memory, cognition, pattern recognition, the control of movement, and a wide range of nervous system diseases including epilepsy, aphasia and movement disorders, e.g. ataxia and Parkinsonian dyskinesia. However, the way in which the necessary information is encoded in the complicated dynamics of these networks is poorly understood.

## Complex Adaptive Networks for Computing and Communication

**Leader:** M. Devetsikiotis (Carleton University).

**Members:** M. Barlow (University of British Columbia), A. Borodin (University of Toronto), A. Bose (Carleton University), M. Csorgo (Carleton University), W. Cunningham (Waterloo), D. Dawson (Fields Institute), T. Drwiega (Nortel Advanced Technologies), J. Edmonds (York University), P. Glynn (Carleton University), G. Goddard (Nortel Advanced Technologies), G. Kesidis (University of Waterloo), T. Kostantopoulos (University of Texas at Austin), D. Krizanc (Carleton University), I. Lambadaris (Carleton University), N. Madras (York University), A. Pelc

(Université du Québec à Hull), J. Rao (Carleton University), B. Richter (Carleton University), N. Santoro (Carleton University) and R. Srinivasan (University of Saskatchewan).

**Industrial Affiliates:** Nortel Networks.

**Problem Statement:** Prompted by envisioned advances in telecommunication technology, the study of computing and communication networks has become an important research activity in computer science and communication engineering. The growing complexity of high-speed networks makes the incorporation of advanced mathematical methodology important for achieving efficient designs.

## Elliptic Curve Cryptography and Algebraic Combinatorics

**Leader:** S. Vanstone (University of Waterloo).

**Members:** A. Agnew (University of Waterloo), D. De Caen (Queens University), C. Godsil (University of Waterloo), I. Goulden (University of Waterloo), A. Hasan (University of Waterloo), D. Jackson (University of Waterloo), B. Martin (University of Winnipeg), A. Menezes (University of Waterloo), D. Stinson (University of Waterloo), J. van Rees (University of Manitoba) and H. Williams (Certicom Corporation).

**Industrial Affiliates:** Certicom Corporation.

**Problem Statement:** Information is recognized by many organizations as an important asset. Few businesses could function effectively without relying on information as a resource. Information security is concerned with providing assurance about the secrecy and authenticity of data, and is of strategic importance in today's world of open networks and electronic data. Cryptography has enormous potential for providing information security services in real-world applications. From basic credit card authorization to wireless transactions, cryptography provides security and enhances the efficiency of electronic commerce. A recent breakthrough is the digital signature that provides verifiable validation for electronic communications.

Elliptic curve cryptography appears to be especially attractive for implementation in computationally

constrained environments such as smart cards, pagers, cellular phone and PDA's. The focus of this project is to carry out research on the security and implementation of elliptic curve cryptosystems, as well as their applications in electronic commerce, internet security, telecommunications and wireless communications.

## Building and Modeling Cellular Automata using Semiconductor Nanostructure

**Leader:** H. Ruda (University of Toronto).

**Members:** M. Allmang (University of Western Ontario), A. Lawniczak (University of Guelph), T. Lookman (University of Western Ontario), Z-H. Lu (NRC), A. Venetsanopoulos (University of Toronto) and B. Yacobi (Energenius Incorporation).

**Industrial Affiliates:** Energenius Incorporated and Nuptek.

**Problem Statement:** Although there have been few reports of modeling quantum cellular automata, these models have been restricted to relatively simple one-dimensional systems only a few cells long. In addition there have been no practical devices of this sort fabricated. However, even from this limited work, it is clear that such systems offer unique advantages for information processing. The proposed extension of models to two dimensional networks, and building and characterizing real systems should provide ground rules for building real computational systems.

# Fields-MITACS: Research-based Innovation

A \$14.5 million grant was awarded to The Mathematics of Information Technology and Complex Systems (MITACS) by the federal Government to encourage networking between the business and technology sector and the field of mathematics.

Many complex problems arising in industry are mathematics based, says MITACS Network Business Manager and Chief Administrative Officer Brenda Law. "We want to utilize the talent in Canada and to encourage new research ideas" to be able to meet the demands of industry.

The Networks of Centres of Excellence grant will be released over a four-year period to start-up and fund several new projects in addition to the 21 already in motion; seven of which are run in cooperation with the Fields Institute; three in bio-medicine, two in information technology, one in manufacturing and one in trading and finance.

The Fields Institute signed an agreement with MITACS on February 22, 1999 to facilitate the surging interest in research and development between science and technology and mathematics. The Centre recherches mathématiques in Montreal (CRM), and the Pacific Institute for the Mathematical Sciences (PIMS) in Vancouver; along with two hospitals, Montreal Heart Institute and Mount Sinai Hospital; and 26 Canadian universities have also signed the agreement with MITACS.

The NCE network connects over 200 companies in industry. The active involvement of Canadian industry provides stimulating training environments and employment opportunities for students, with nearly 97% of network graduates finding jobs. In 1997 to 1998, a total of 463 companies, more than 100 provincial and federal government departments and agencies, 44 hospitals, 61 universities, and more than 200 other organizations from Canada and abroad were involved in the NCE program.

MITACS already links 188 academic researchers with applied mathematicians from 34 companies which have signed on to work together to solve industry problems. The industrial partners are similar to Algorithmics Incorporated of Toronto, Ontario in that they either owe their existence to complex mathematical problems or utilize advanced mathematics to innovate.

"This is a huge boost for mathematics researchers in Canada and for students wanting to pursue careers in applied math," says Dr. Stephen Halperin, head of the MITACS network. Dr. Halperin added that the bulk of the funding will be for research students, including an industrial postdoctoral program that will support research by mathematicians employed by business.

MITACS is unusual because of its decentralized structure, the company as a whole consists of three nodes, dispersed Canada-wide. Fields-MITACS, situated on the University of Toronto St. George Campus, the CRM in Montreal, and PIMS in Vancouver form the triad. Telecommunications, financial risk management and bio-medicine are among the key areas that MITACS and corporate partners have selected for research priorities. Nortel Networks and Canadian Imperial Bank of Commerce are among other firms that plan to work with MITACS.

The coming year promises to be a busy one for project leaders and network investigators as the Fields-MITACS project teams develop their body of research, train researchers in the development and application of mathematical models, and build industrial partnerships. We have laid the groundwork at the Fields Institute to support these research projects and we look forward to their continued development.

For more information on MITACS  
visit the web-site at  
<http://www.mitacs.math.ca>

## Fields-MITACS Developments

The Fields Institute provides administrative and scientific support to the following seven projects under the direction of Director Donald Dawson, Research Liaison Officer Ben Schwartz, Accountant Uma Gupta, and Administrative Assistant Alison Conway. The team creates and administers Fields-MITACS network connections.

Our bio-medical projects draw team members from coast to coast; from Memorial University in Newfoundland to the University of Victoria, and include research on statistical modeling and analysis of complex traits in human populations by leading scientific investigator, Dr. Shelley Bull of the Samuel Lunenfeld Institute at Mount Sinai Hospital. Dr. John Hsieh, of the Department of Public Health Sciences, University of Toronto has undertaken exciting research in the area of mathematical and computer modeling of epidemics with public health applications. Dr. Sue Ann Campbell at the University of Waterloo leads the Modeling and Analysis of Networks of Neurons project. The Fields Institute hosted project meetings over the past months for these projects and provided support for networking and communications.

The information technology projects based at the Fields Institute include research on complex adaptive networks for computing and communication lead by Dr. Mike Devetsikiotis of Carleton University. Network investigators on this project include familiar faces such as our own Don Dawson, Director of the Institute and Raj Srinivasan; a Fields Institute affiliate member from the University of Saskatchewan. The other project in this theme involves research on applied cryptography with project leaders Scott Vanstone and Doug Stinson based at the University of Waterloo. Both Scott Vanstone and network investigator Alfred Menezes gave papers at the recent Conference on the Mathematics of Public-Key Cryptography hosted by the Fields Institute.

Dr. Harry Ruda of the University of Toronto leads the Fields-MITACS manufacturing project that involves building and modeling semiconductor nanostructures using cellular automata. Team members come from the University of Western Ontario, Guelph University and the University of Toronto and include Anna Lawniczak who is also a visiting member to the Probability program.

Stimulating research is being done in the trading and finance sector with Luis Seco's project on The Mathematics of financial risk. Dr. Seco is from the University of Toronto's Mathematics Department and is well known for his work with RiskLab. Team member Georges Dionne of École des Hautes Études Commerciales de Montréal was recently honoured with the prestigious Marcel-Vincent de l'Acfas prize. The research that these projects have undertaken has generated attention and stimulated discussion within their respective research communities. In May, the MITACS trading and finance theme meeting was hosted by the Institute and it brought together many of the network investigators in this area. The official launch of the theme was held in conjunction with the Fields Institute Seminars in Financial Mathematics in May.

# HIGHLIGHTS OF THE INSTITUTE'S COMMUNITY

Congratulations to the following individuals for their outstanding performance in their area of research.

## Canada Gold Medal for Science and Engineering

Dr. **James Arthur** of the University of Toronto is the first mathematician to receive the distinguished Canada Gold Medal presented by the Natural Sciences and Engineering Research Council of Canada. The award recognizes his work in automorphic forms and representation theory, particularly his innovative trace formula, and “Arthur” packets which present new approaches to the Langlands program, an ambitious and far-reaching theoretical mathematical model.

“The Gold Medal is fitting recognition for his contributions to Canada, for his extraordinary career at the forefront of international research, and for his success in helping (to) establish Toronto as a world-class centre for mathematics,” said Tom Brzustowski, President of NSERC.

Dr. Arthur has been a strong supporter of the Institute for many years and was awarded the CRM-Fields Prize in 1997.

## The McLean Award

Professor Boris Khesin won the University of Toronto's Annual \$100,000 McLean Award for his research in an extraordinarily wide range of topics in geometry and theoretical mathematical physics. The 34-year-old Russian refers to himself as a builder of bridges between mathematical fields.

Professor Khesin is a member of the organizing committees for two up-coming Fields Institute programs; Infinite Dimensional Lie Theory and Its Applications (September to December 2000) and Symplectic Topology, Geometry and Gauge Theory (January to June 2001).

## Premier's Research Excellence Awards

The Premier's Research Excellence Awards (PREA) program was designed to help gifted researchers attract talented people to their research teams. The award is based on the excellence of the research potential as demonstrated in part by scientific and academic contributions to date, and the importance or promise of the proposed area of research. The Board of PREA looks for researchers who can "make a difference" through the excellence of their work, the vision that they bring to their endeavours and the impact that they foresee resulting from their work.

The following mathematical science members of our partner universities have won the award this past year: Ioannis Lambadaris (Department of Systems and Computer Engineering, Carleton University), Radford M. Neal (Department of Statistics, University of Toronto), Lisa C. Jeffrey (Department of Mathematics, University of Toronto), Richard J. Cook (Department of Statistics and Actuarial Science, University of Waterloo), and Levent Tunçel (Department of Combinatorics and Optimization, University of Waterloo).

## The John L. Synge Award

Professor George Elliott received the John L. Synge Award in 1999. The Award was established in 1986 by the Royal Society of Canada to honour John Lighton Synge, one of the first mathematicians working in Canada to obtain international recognition for research in mathematics. The Award is given for outstanding research in any of the branches of the mathematical sciences. The previous recipients were James Arthur, Israel Michael Sigal and Joel Feldman.

Professor Elliott has been with the Fields Institute for such a long time that he has almost become a fixture of the place. He was the organizer of the highly successful thematic program on Operator Algebras. He is currently a Senior Distinguished Member of the Institute.

# MANAGEMENT STRUCTURE

The Fields Institute was incorporated in 1994 and is governed by the Ontario Incorporation Act as well as the bylaws of the Institute. There are seven classes of membership in the Corporation and the membership of 1998-99 can be seen below. The members of the Corporation attend the Annual General Meeting and are responsible for approving the scientific and budgetary commitments of the Institute, appointing auditors, electing directors, and other business as required. The members of the Corporation elect representatives to the Board of Directors from their membership.

The Board of Directors meets at least three times per year to ensure that the Institute is fulfilling its mandate for research, mathematics education and outreach. The Board operates with the help of a number of committees. An Executive Committee is formed from the membership and is responsible for supporting the Chairman in responding to the day-to-day, operational concerns of the Institute. The Scientific Nominating Committee (SNC) is elected by the Board from the Corporation membership and is responsible for the selection of the Director and Deputy Director of the Institute. The SNC is also responsible for suggesting members for the Scientific Advisory Panel (SAP). A Board Nominating Committee (BNC) is formed from the Board's membership and is responsible for monitoring Board terms and finding replacement members for the Board of Directors.

All of the representatives of the Corporation are important in representing the diversity of the mathematical sciences but the members from the Principal Sponsoring Universities and the Affiliate Universities play a unique and crucial role in the Institute's scientific activity. These members play a role in the administration of the Institute and they are represented on the Board with a regular rotation scheme so that each university is given representation in the decision-making process.

The Director and the Scientific Advisory Panel provide the scientific leadership of the Institute. The SAP, which is chaired by the Director, includes the Deputy Director and a rotating membership of at least 10 distin-

guished international mathematicians. This committee makes recommendations to the Board of Directors on the selection of thematic programs and workshops.

The daily management of all aspects of the Institute is the responsibility of the Director and the Deputy Director; whose responsibilities are set out in detail in the Institute Bylaws. The Manager of Finance and Operations, the Executive Assistant and the Director of Computing Systems assist them.

The management of each research program is the responsibility of the Director, the Program Committee and the Institute Staff. The Program Committee, comprised of scientists closest to the research activities of the program, has the primary responsibility of inviting visiting scientists, appointing postdoctoral fellows, and organizing workshops, conferences, seminars and graduate lecture series. Throughout the planning and implementation of each event, the organizing committees are advised by the Director and by the management staff, in particular the Manager of Finance and Operations, the Program Coordinator, the Workshop Coordinator and the Housing Officer. The accumulated experience of previous Institute programs is thus made available to each new Program Committee.

The management of the Mathematics Education component of the Institute's activity is the responsibility of the Deputy Director. A Mathematics Education Advisory Panel (MEAP) reviews proposals for education activities.

Management of the finances and operations of the Institute is the responsibility of the Director. The Manager of Finance and Operations monitors expenditures; is responsible for the recruitment, training and supervision of scientific support staff; and assists the Director in long-range operational planning. The administrative functions of the Institute and the activities of the Corporate Members, the Board of Directors, the Scientific Advisory Panel, and the Directorate are coordinated by the Executive Assistant. The Communications Officer is responsible for public relations and advertising.

# Institute Personnel

## DIRECTOR'S OFFICE

Donald DAWSON	Director
William LANGFORD	Deputy Director
Cherryl BIRD	Communications Officer/Director's Administrative Assistant
Sue EMBRO	Manager, Finance & Operations
Becky SAPPONG	Executive Assistant to the Director

## ADMINISTRATION

Pauline GRANT	Receptionist/Administrative Assistant
Uma GUPTA	Accountant

## SCIENTIFIC SUPPORT

Kim COOPER	Housing Coordinator
Jan DAY	Program Coordinator/Librarian
Maria FOUDOLOVA	Assistant to the Deputy Director/Workshop Coordinator
Phillip SPENCER	Director Computing Services
Alesia ZUCCALA	Publications Manager

## FIELDS-MITACS NETWORK

Alison CONWAY	Administrative Assistant
Ben SCHWARTZ	Research Liaison Officer

# Members of the Corporation 1998-99

## Directorate Members

Donald Dawson      Director  
William Langford    Deputy Director

## Principal Sponsoring University Members

John Bland            Department of Mathematics, University of Toronto  
Alan George          Dean, Faculty of Mathematics, University of Waterloo  
Andrew Nicas        Department of Mathematics and Statistics, McMaster University  
George O'Brien      Department of Mathematics, York University  
Josef Paldus         Department of Applied Mathematics, University of Waterloo  
Robert Prince        Dean, Department of Pure and Applied Science, York University  
Peter Sutherland     Dean, Faculty of Science, McMaster University  
Safwat Zaky          Faculty of Applied Science and Engineering, University of Toronto

## Host University Administrative Member

Stephen Halperin    Chair, Department of Mathematics, University of Toronto

## Affiliate University Members

Lynn Batten          Department of Mathematics, University of Manitoba  
Stephen Berman      Department of Mathematics, University of Saskatchewan  
Oleg Bogoyavlenskij   Department of Mathematics and Statistics, Queen's University  
Cyril Garner         Ottawa-Carleton Institute for Mathematics and Statistics  
Richard Jardine      Department of Mathematics, University of Western Ontario  
Anna Lawniczak      Department of Mathematics and Statistics, University of Guelph  
Richard Wood        Atlantic Association for Research in Mathematical Sciences - AARMS  
(In association with Dalhousie University, Memorial University, and the University of New Brunswick)

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Richard Kane         Canadian Mathematics Society  
Donald McLeish      Statistical Society of Canada  
Nicholas Derzko      Canadian Applied & Industrial Mathematics Society

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# Scientific Advisory Panel

## 1998-1999

Our Director and the Scientific Advisory Panel (SAP) provide the scientific leadership of the Institute. The SAP, which is chaired by the Director, includes the Deputy Director and a rotating membership of at least ten distinguished international mathematicians. This committee makes recommendations to the Board of Directors on the selection of thematic programs and workshops.

John Chadam is a graduate of the MPC program at the University of Toronto and did his graduate work at MIT. He earned his PhD in 1965 with a dissertation on Nonlinear Relativistic Wave Equations supervised by I. Segal. He is currently the Chair of the Department of Mathematics at the University of Pittsburgh, where he has been since the end of his term as Director at the Fields Institute. Prior to this he was in the Mathematics Department at Indiana State University and at McMaster University. During these two academic appointments, Professor Chadam visited several international mathematics institutes. His recent research interests include free boundary problems. With Ortoleva he delineated the so-called reaction-infiltration instability for interfaces in reacting flows in porous media. This concept arises in a wide class of geological phenomena and the idea is now incorporated into many water-rock interaction computer codes. He is active in many professional societies and organizations. He was the past President of the Canadian Applied Mathematics Society, NSERC's ad hoc committees of Pure and Applied Math GSC, Editor of the Canadian Applied Math Quarterly, and Chair of the NSERC Collaborative Research Grant Physical Sciences committee, 1994 to 1997.

Donald Dawson is the Director of the Fields Institute for Research in Mathematical Sciences. He received his Honours B.Sc. in Mathematics and Physics from McGill in 1958 and his doctorate from MIT in 1963. He has taught at both McGill University and Carleton University and has been a co-director of the Carleton-Ottawa Laboratory for Research in Statistics and Probability since 1982. His research interests include large deviation theory, stochastic differential equations, stochastic partial differential equations, measure-valued processes and applications of probability to statistical physics, genetics, finance and optimization. He is a Fellow of the Royal Society of Canada. He has given numerous invited lectures; including the 1991 Gold Medal

Lecture of the Statistical Society of Canada, the 1994 Jeffery-Williams lecture of the Canadian Mathematical Society, a lecture at the 1994 International Congress of Mathematicians in Zurich, and a plenary lecture at the 1996 World Congress of the Bernoulli Society in Vienna. He has been a member of the editorial boards of a number of journals and Co-Editor-in-Chief of the Canadian Journal of Mathematics in 1988 to 1993. He has served on a number of NSERC committees including the Mathematics and Statistical Sciences GSC's, Research Manpower, Postdoctoral Fellowship, International Relations and the 1995 Task Force on Strategy Implementation.

Joel Feldman received his PhD in physics from Harvard University in 1974. He spent one year as a postdoctoral fellow at Harvard and two years as a C. L. E. Moore Instructor at MIT before moving to the University of British Columbia in 1977. Except for a number of leaves spent at the École Polytechnique in Paris and the ETH in Zurich, he has been there ever since. He has been honoured with an invitation to speak at the 1990 International Congress of Mathematicians in Kyoto, an election to the Royal Society of Canada, awarded the UBC Killam Research Prize and the John L. Synge Award of the Royal Society of Canada. His area of research is mathematical physics and he is currently working on a program to develop a mathematical theory of super-conductivity.

John Friedlander received his PhD from Pennsylvania State University in 1972. Currently he is a Professor of Mathematics at the University of Toronto, where he was the Chair of the Department of Mathematics. Prior to his current position, Friedlander has been at the Institute for Advanced Study at Princeton as both a member and a visiting lecturer. His career as a visiting professor has taken him to several international institutions; the most recent of which was Macquarie University in Australia. His research area is analytic number theory. He received the CMS Jeffrey-Williams Prize in 1999 and gave the prize lecture at the CMS Summer Meeting in June 1999. He also gave an invited lecture at the 1994 International Congress of Mathematicians in Zurich. He was elected Fellow of the Royal Society of Canada in 1988 and is a member of several editorial boards. Dr. Friedlander has served on two NSERC committees.

Avner Friedman received his Doctorate from Hebrew University in 1956. He has held several visiting positions throughout his career; including, Assistant Professor, University of California, Berkeley (1958-59); Visiting Associate, Stanford University (1961-62); Visiting Professor, Tel Aviv University (1966-67 and 1970-71). In addition to these visiting positions, he was a full Professor at Northwestern University (1962-86) and Duncan Distinguished Professor of Mathematics, Purdue University (1985-88). Dr. Friedman is currently a Professor at the University of Minnesota and the former Director of the Institute for Mathematics and its Applications and is serving as Director of the Minnesota Center for Industrial Mathematics. Throughout his career, Dr. Friedman has received several significant awards and honours, these include the Sloan Fellowship in 1962 to 1965; the Guggenheim Fellowship in 1966 to 1967; recipient of the Stampacchia Prize in 1982; the National Science Foundation Special Creativity Award in 1983 to 1988, 1991 to 1993 and the National Academy of Sciences in 1993. He has served as the President of the Society for Industrial and Applied Mathematics from 1993 to 1995, and is currently the Chair on the Board of Mathematical Sciences.

Mark Goresky received his PhD from Brown University in 1976. He became an instructor at MIT in 1976 until 1978. From 1978 to 1981 he held the position of Assistant Professor at University of British Columbia. Dr. Goresky joined the faculty at Northeastern University (Boston) in 1981 as a joint Professor of Mathematics and Computer Science. He moved to Princeton in 1994. He has been awarded many honours over the course of his career; these include elected a Fellow of the Royal Society of Canada; the Sloan Fellowship, a Coxeter-James lectureship and the Jeffrey-Williams Prize. Dr. Goresky served on NSERC Grant Selection Committee for Mathematics (for 3 years), the committee for the Review of Canadian Mathematics (NSERC), Committee of Visitors for Algebra and Number Theory (NSF), selection committee for Group Infrastructure Grants (NSF), and selection committee for Postdoctoral Fellowships (American Mathematical Society).

Barbara Keyfitz received her undergraduate education at the University of Toronto and her MS and PhD from New York University's Courant Institute in 1970. She is now Professor of Mathematics and a John and Rebecca Moores University Scholar at the University of Houston. She is a Fellow of the American Association for the Advancement of Science and serves on the editorial boards of the SIAM Journal of Applied Mathematics, the Transactions of the AMS and Mathematical Methods in the Applied Sciences. Before joining the faculty at the University of Houston in 1983, she was a faculty member in Engineering at Columbia and Princeton, and in mathematics at Arizona State University. She has also held visiting positions at the University of Nice, at Duke University, at Berkeley, at the Institute for Mathematics and its Applications in Minneapolis and at the Fields Institute in Canada. She is Vice President for Programs for the Society for Industrial and Applied Mathematics.

William Langford currently serves as the Deputy Director of the Fields Institute. He is a professor and the former Chair of the Department of Mathematics at the University of Guelph. He received his PhD from the California Institute of Technology in 1971 and has been a faculty member at McGill University (1970-82) and Adjunct Professor at the University of Waterloo (1983-95). Langford has been a visiting scientist at the University of Nice, the University of Houston, Tianjin University (China), the University of Warwick and the Institute for Mathematics and its Applications (Minnesota). His main research activities are in dynamical systems theory and bifurcation theory, and their applications to physical and biological systems. He has served as a member and chair of the NSERC Applied Mathematics GSC in 1996 to 1997. In 1998, he delivered the 31<sup>st</sup> Harry Gehman lecture of the Mathematical Association of America and a plenary lecture at BTNA in Xian, China.

François Lalonde received his B.Sc. in physics and B.Sc. in mathematics at Université de Montréal. He was granted his doctorate from Université du Paris-Orsay, and did postdoctoral work at the Institut des Hautes Études Scientifiques (Paris). His area of research is symplectic geometry and topology and in particular on the role of symplectic capacities. Dr. Lalonde was an NSERC University Research Fellow and Associate Professor at Université du Québec à Montréal since 1985 and became a full Professor in 1993. He served as Director of the Institut des Sciences mathématiques and Chair of NSERC's Grant selection committee in pure mathematics in 1997 to 1998. Dr. Lalonde was elected Fellow of the Royal Society in 1997.

William R. Pulleyblank is the Director of Mathematical Sciences in IBM's Research Division and the Director of the IBM Deep Computing Institute. He is also the Research Relationship Executive responsible for the Finance sector at IBM. Previously he was the Relationship Executive for the Utility and Energy Services industry and for the Business Intelligence group. He is currently a member of the Mathematical Sciences Board of the NRC, the External Advisory Board of DIMACS, the Advisory Council of the Pacific Institute for the Mathematical Sciences, the External Advisory Committee of the Center for Research on Parallel Computation, and RUTCOR, Rutgers University International Conferences on Discrete Applied Mathematics and Operations Research International Advisory Board.

Dr. Pulleyblank's personal research interests are in operations research, combinatorial optimization, and applications of optimization. In addition to writing a number of scientific papers and books, he has consulted for several companies; including, Mobil Oil on helicopter routing, Marks and Spencer on depot management, Statistics Canada on survey validation and CP Rail on train scheduling.

Nancy Reid is Professor and Chair of the Department of Statistics at the University of Toronto. She received her Bachelor of Mathematics in 1974 from the University of Waterloo, her PhD in 1979 from Stanford University, and held an academic appointment at the University of British Columbia from 1980 to 1986. She is a former President of the Institute of Mathematical Statistics, and a current Vice-President of the International Statistical Institute. She is a fellow of the American Statistical Association and the Institute of Mathematical Statistics, a recipient of the Presidents' Award of the Committee of Presidents of Statistical Societies, and the first recipient of the Canadian Mathematical Society's Krieger-Nelson Prize Lectureship.

Her research interests include design of experiments, theory of inference, and asymptotic methods for likelihood based inference. Recent publications include several papers on the relationship between frequentist and Bayesian asymptotics, a topic of current interest in relation to the search for noninformative priors for Bayesian inference. She has also given several talks recently for non-specialist audiences, on various aspects of "Statistics in the News".

David Sankoff received his PhD from McGill University in 1969. He has worked in the field of computational biology, and in particular in the areas of sequence comparison, multiple alignment, RNA secondary structure and probabilistic methods. He developed the "empirical method" for discovering non-linear phylogenetic invariants. In the early 90's, he was responsible for stimulating the study of evolution through the mathematical analysis of genome arrangements. He is a member of the Centre de recherches mathématiques and a Fellow of the Royal Society of Canada and of the Canadian Institute for Advanced Research.

# The Fields Institute Committees

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## Scientific Nominating Committee

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Joel Feldman (University of British Columbia)  
John Friedlander (University of Toronto)  
John R. Gardner (Fields Institute)  
William Langford (Fields Institute)  
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E. Muller (Canadian Mathematics Education Study Group)  
B. Onslow (Ontario Association for Mathematics Education)  
R. Scoins (University of Waterloo)  
C. Simson (Nortel Networks Ltd.)  
M. Warren (Ontario Mathematics Coordinators Association)

# THE NETWORK OF UNIVERSITY PARTNERS

Our Sponsoring and Affiliate Universities provide the Fields Institute with a strong scientific base and an immediate link with an exceptional pool of talent. The representation of these institutions as Members of the Corporation and of the Board of Directors ensures their input into the policy decisions of the Institute.

As a result of requests from our community the Institute has introduced a new program, the University Partners Program which funds activities at the partner universities. The program will be implemented in 1999. As a benefit of membership, the Fields Institute reserves space and facilities for faculty to spend sabbatical or other research leaves at the Institute. In addition, special arrangements are made for teaching release for members of organizing committees from these universities. The Fields Institute Monographs and Communication volumes are distributed to the mathematics departments of our partners.

The Institute currently has four Principal Sponsoring Universities and ten Affiliate Universities. The partner Universities support the Institute with membership fees but by far, the greatest contribution that they make is to provide a resource of talented researchers. The Institute relies on the ideas and energy of these individuals and departments to lead events like our thematic program, workshops and seminars. As well, the community provides leadership, ideas and direction to the management of the Institute.

## Profiles of the Principal Sponsoring Universities

### McMaster University

McMaster University is a research-intensive, mid-sized university located in Hamilton at the west-end of Lake Ontario. Its Mathematics and Statistics Department has 31 faculty members who represent a wide range of mathematical research including algebra and number theory, analysis, geometry and topology, applied mathematics, probability and statistics and mathematical logic. The department has an extensive postdoctoral program with about 15 positions each year and a graduate program with over 40 students. As one of the founding universities, McMaster's contribution to the Fields Institute has been substantial. Faculty members from McMaster were principal organizers of four of the first seven full-year programs at the Fields Institute, and there have been more than 15 joint McMaster-Fields postdoctoral fellowships.

### University of Toronto

The Department of Mathematics at the University of Toronto is the leading mathematics research department in Canada and ranks among the stronger departments in North America. The Department is a distinguished faculty of more than sixty mathematicians. Mathematics has been taught at the University of Toronto since 1827. The first Professor of Mathematics was appointed in 1843, and the first PhD in mathematics was conferred in 1915 to Samuel Beatty, who was a student of John Charles Fields. Samuel Beatty went on to a position in the Department of Mathematics at the University of Toronto, subsequently becoming Head, Dean of the Faculty, and then Chancellor of the University.

Since then more than 300 PhD degrees in Mathematics have been awarded at this University. The majority of recent graduates are engaged in university teaching and significant numbers hold administrative positions in universities or in the professional communities. The mathematics undergraduate program at the University of Toronto is considered to be one of the best in North America. Many undergraduates who study mathematics at the University of Toronto have continued their education by doing graduate work at some of the best

colleges and universities in North America and Europe. The University has been well represented in mathematical competitions, including the Putnam Competitions and the Mathematical Contest in Modeling. Opportunities for graduate study and research are available in most of the fields of pure and applied mathematics.

## University of Waterloo

The University of Waterloo's Faculty of Mathematics is known for its innovation and leadership in education, research and technology transfer. With a population of 3,000 undergraduate, 250 graduate students, and 132 full-time professors, Waterloo ranks as the largest centre for mathematical and computer sciences in the world. The Faculty of Mathematics offers a broad range of studies through five departments: Applied Mathematics, Combinatorics and Optimization, Computer Science, Pure Mathematics, and Statistics and Actuarial Science. Widely known for its accomplishments in computer science, it also has exceptional strength and stature in discrete mathematics, applied statistics, and actuarial science. Recently, cryptography has seen rapid development with the appointment of two NSERC industrial chairs. The Faculty of Mathematics generated \$12.6 million in research funding last year. With the University's liberal position on intellectual property, research conducted in the Faculty has resulted in over 100 spin-off companies founded by professors, students and graduates.

The Faculty of Mathematics consistently attracts the best students from around the world. Waterloo has won the world championship Association for Computing Machinery (ACM) Programming Competition twice and placed in the top 10 in each of the past seven years. As well, Waterloo has placed in the top five in the Putnam Competition seven times in the past decade. As many as seven percent of the top 200 students in the competition are from Waterloo. For six years in a row, a group of more than 3,500 senior administrators, company presidents, and academic counsellors surveyed by Maclean's, Canada's national magazine, judged the University of Waterloo to be the "Best Overall" university in Canada.

## York University

The Department of Mathematics and Statistics at York University is home to a diverse group of scholars. Faculty members are active in research and publication in

virtually all the major fields of mathematics and statistics. In particular, York has significant representation in several general areas including foundations of mathematics, probability and stochastic theory, analysis (differential equations and dynamics) and applied mathematics, algebra and geometry, and statistics. The quality of scholarly work produced by members of the department is attested to by its external grant support and recognition. The Department has consistently been one of the top recipients of mathematics and statistics research grants by NSERC. In a 1995 study conducted by the US-based Institute for Scientific Information, which looked at the scientific impact of papers published in top journals on the basis of citations, mathematics at York University ranked second in Canada with respect to other mathematics departments.

The Department is equally proud of its thriving graduate program. In addition to the regular MA and PhD degree programs, the Department offers a long-standing MA Program for Teachers, which is designed to enhance the breadth of knowledge of high school mathematics teachers and their effectiveness in the classroom. Starting from the academic year 1998-99, the programme has been offering the Graduate Diploma in Financial Engineering, in collaboration with the Schulich School of Business. The diploma programme is designed to provide the relevant training in finance, mathematics, and computer science which is necessary to understand, design and value new financial instruments. York is also one of the three Canadian Universities participating in the project "Atlantis" funded by the Canada-European Community Program for Cooperation in Higher Education and Training. The program allows senior undergraduate and graduate students in mathematics and computer science to earn credit at York while studying in Belgium, Italy and Portugal.

## Our Affiliate Universities

Atlantic Association for Research in Mathematical Sciences (Dalhousie University, Memorial University of Newfoundland and University of New Brunswick)  
Ottawa-Carleton Institute for Mathematics and Statistics  
Queen's University  
University of Guelph  
University of Manitoba  
University of Saskatchewan  
University of Western Ontario

# COMPUTING FACILITIES

The past year has brought significant improvements to the computing facilities at the Fields Institute. Substantial changes have been made in the organization of both the research computing (Unix) and administrative computing (Windows NT) environments.

The overall increase in the volume of traffic at the Institute demanded new ways of using the equipment. We have introduced new scientific software applications and restructured the internal use of our systems to get the most out of existing equipment. We have also introduced electronic registration on our web-site to deal with the influx of traffic.

In 1998, the Institute with the help of the Computing Advisory Committee was successful in garnering an NSERC Equipment Grant. This grant has been used to purchase of eleven Pentium II based workstations which give visitors access to both the Linux and Windows NT Operating Systems as well as the central server. A second NSERC Equipment Grant application was approved and the funds will be used to upgrade the Institute's server.

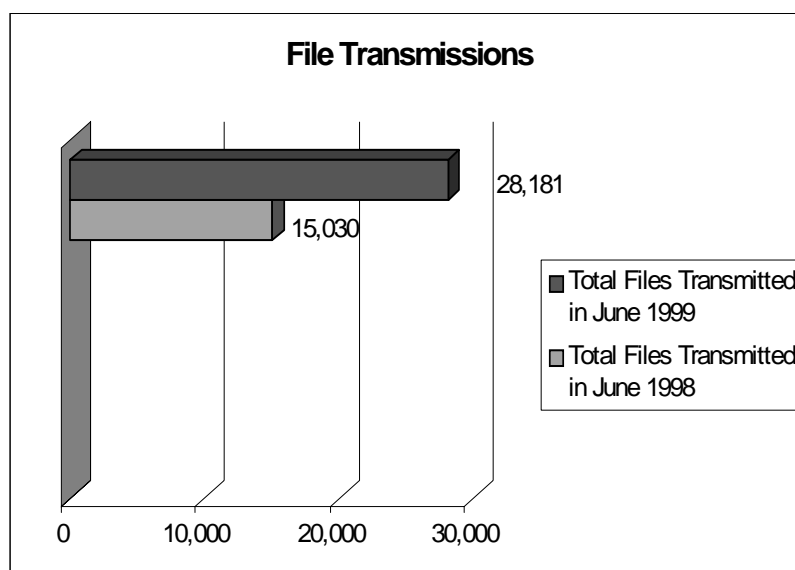
With some persistence and hard work, Dr. Philip Spencer negotiated a contract with IBM for a significant upgrade to our central Unix server and the installation will take place this summer.

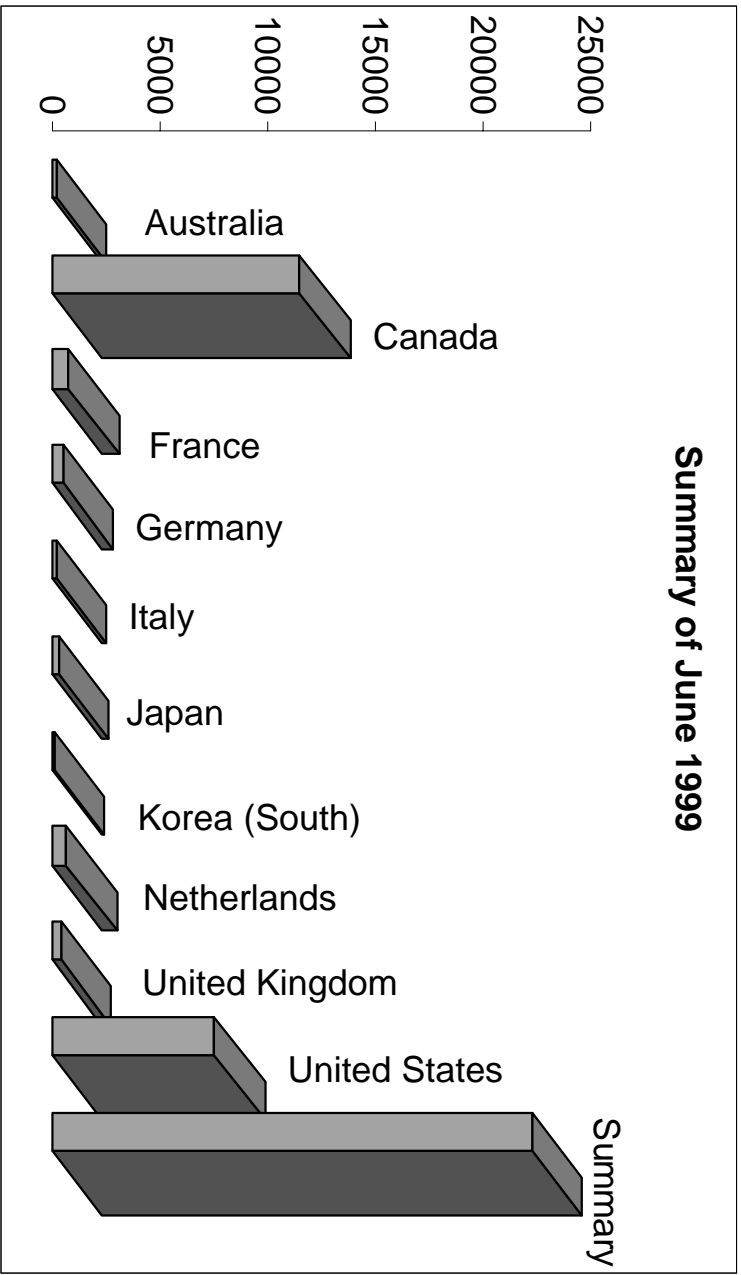
## The Fields Institute Web-site

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Access to the Fields Institute web-site increased by 87.5 percent over one year. In June of 1999, the number of hits increased to 28,181 whereas in the fiscal year ending in June 1998, files from the Institute's world wide web-site were accessed 15,030 times.

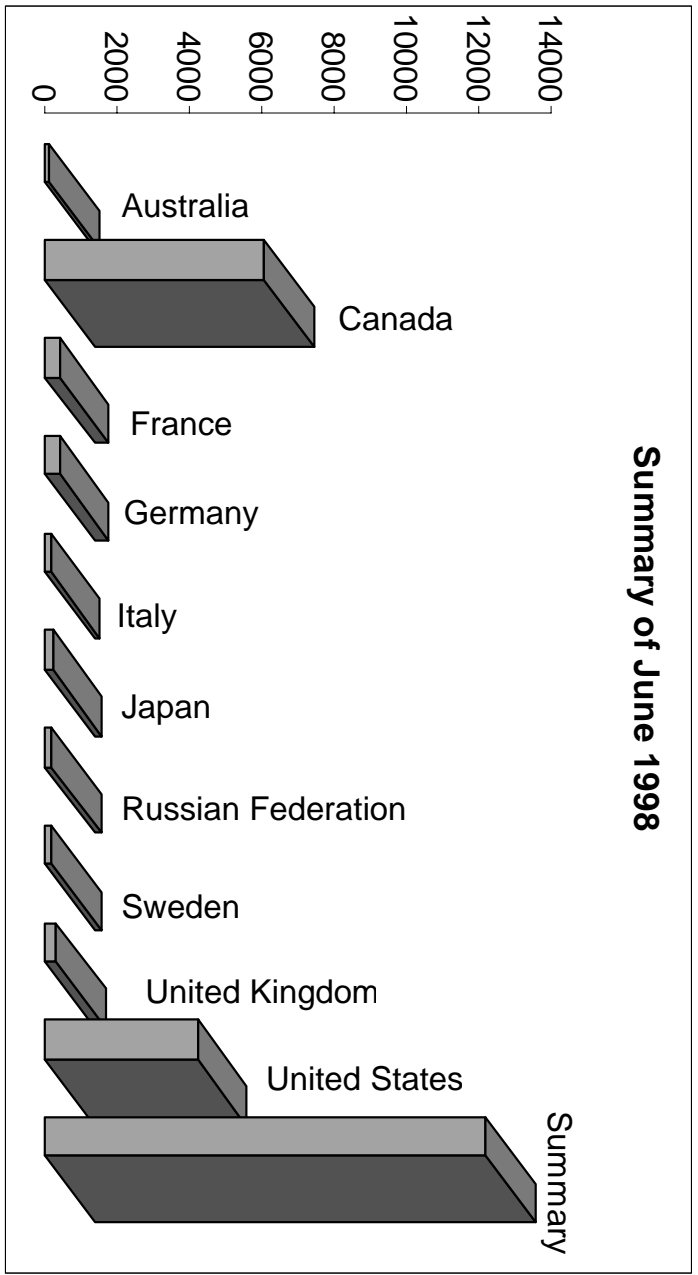
Based on domain names, a majority of the web-site requests came from within Canada (11,510), followed by the United States, including commercial and educational institutions (7,560) and France (785) in June 1999. The top three countries in June 1998 were Canada (6,070), the US combined (4,202) and Germany (390).





Top 10 Hits

[www.fields.utoronto.ca](http://www.fields.utoronto.ca)



# PUBLICATIONS

## Fields Institute Monographs

1. Global Dynamics, Phase Space Transport, Orbits Homoclinic to Resonances, and Applications, by Stephen Wiggins, California Institute of Technology, AMS, 1993, 155pp.
2. Galois Module Structure, by Victor Snaith, McMaster University, AMS, 1994, 207pp.
3. Lectures on Operator Theory and Its Applications, ed. P. Lancaster, University of Calgary, AMS, 1996, 339pp.
4. Riemannian Geometry, eds. M. Lovric, M. Min-Oo and Y-K Wang, McMaster University, AMS, 1996, 115pp.
5. Multiplicative Galois Module Structure, by A. Weiss, University of Alberta, AMS, 1996, 95pp.
6.  $C^*$ -Algebras by Example, by K. R. Davidson, University of Waterloo, AMS, 1996, 309pp.
7. Bordism, Stable Homotopy and Adams Spectral Sequences, by S. O. Kochman, York University, AMS, 1996, 272pp.
8. Lifting Solutions to Perturbing Problems in  $C^*$ -algebras, by T. Loring, University of New Mexico, AMS, 1997, 165pp.
9. Introduction to Homotopy Theory, by P. Selick, University of Toronto, AMS, 1997, 188pp.
10. Quasi-Crystals and Discrete Geometry, ed. by J. Patera, Université de Montréal, AMS, 1998, 289pp.
11. Shape, Smoothness and Invariant Stratification of an Attracting Set for Delayed Monotone Positive Feedback, by Tibor Krisztin, University of Szeged, Bolyai Institute, Hans-Otto Walther, Universität Giessen, and Jianhong Wu, York University, AMS, 1999, 256pp.

## Upcoming Volumes

Lectures on Operator Theory, eds. B.V.R. Bhat, G.A. Elliott and P.A. Fillmore.

Ordered Exponential Fields, by S. Kuhlmann.

Large Deviations, by F. den Hollander.

# Fields Institute Communication Series

1. Dynamics and Control of Mechanical Systems: The Falling Cat and Related Problems, ed. Michael J. Enos, The Fields Institute, AMS, 1993, 280pp.
2. Control of Flexible Structures, ed. Kirsten Morris, University of Waterloo, AMS, 1993, 243pp.
3. Hamiltonian and Gradient Flows, Algorithms, and Control, ed. Anthony Bloch, Ohio State University, AMS, 1994, 155pp.
4. Normal Forms and Homoclinic Chaos, eds. W. F. Langford, University of Guelph and W. Nagata, University of British Columbia, AMS, 1995, 294pp.
5. Pattern Formation: Symmetry Methods and Applications, eds. J. Chadam, McMaster University; M. Golubitsky, University of Houston; W. Langford, University of Guelph and B. Wetton, University of British Columbia, AMS, 1996, 358pp.
6. Pattern Formation and Lattice Gas Automata, eds. A. T. Lawniczak, University of Guelph/University of Toronto and R. Kapral, University of Toronto, AMS, 1996, 346pp.
7. Mechanics Day, eds. W. F. Shadwick, The Fields Institute; P. S. Krishnaprasad, University of Maryland and T. S. Ratiu, University of California at Santa Cruz, AMS, 1996, 260pp.
8. Conservative Systems and Quantum Chaos, eds. L. M. Bates and D. L. Rod, University of Calgary, AMS, 1996, 176pp.
9. Nonlinear Dynamics and Stochastic Mechanics, eds. W. H. Kliemann, Iowa State University; W. F. Langford, University of Guelph and N. Sri Namachchivaya, University of Illinois at Urbana-Champaign, AMS, 1996, 238pp.
10. Integration Algorithms for Classical Mechanics, ed. J. Marsden, California Institute of Technology; G. Patrick, University of Alberta and W. F. Shadwick, The Fields Institute, AMS, 1996, 244pp.
11. Nonlinear Dynamics and Time Series: A Bridge Between the Physical and Statistical Sciences, eds. C. Cutler, University of Waterloo and D. Kaplan, AMS, 1996, 252pp.
12. Free Probability Theory, ed. D. Voiculescu, University of California, Berkeley, AMS, 1997, 312pp.
13. Operator Algebras and their Applications, eds. P. Fillmore, Dalhousie University and J. Mingo, Queen's University, AMS, 1997, 323pp.
14. Special Functions, q-Series and Related Topics, eds. M. Ismail, University of South Florida; D. Masson, University of Toronto and M. Rahman, Carleton University, AMS, 1997, 277pp.
15. Sixth Canadian Conference on General Relativity and Relativistic Astrophysics, eds. J. Gegenberg, S. Brahm, and R. McKellar, AMS, 1997, 373 pp.
16. Algebraic K-Theory, ed. V. Snaith, McMaster University, AMS, 1997, 358pp.
17. Cyclic Cohomology and Noncommutative Geometry, eds. J. Cuntz, Heidelberg University and M. Khalkhali, University of Western Ontario, AMS, 1997, 189pp.
18. Topics in Semidefinite and Interior-Point Methods, eds. P. Pardalos, University of South Florida and H. Wolkowicz, University of Waterloo, AMS, 1998, 250pp.
19. Stable and Unstable Homotopy, eds. William G. Dwyer, University of Notre Dame, Steve Halperin, University of Toronto, Richard Kane, University of Western Ontario, Stanley O. Kochman, York University and Paul Selick, University of Toronto, AMS, 1998, 316pp.
20. Operator Algebras and their Applications, Volume II, eds. Peter Fillmore, Dalhousie University and J. Mingo, Queen's University, AMS, 1998, 170pp.

21. *Differential Equations with Applications to Biology*, eds. S. Ruan, Dalhousie University, G. S. K. Wolkowicz, McMaster University and J. Wu, York University, AMS, 1999, 509pp.
22. *Topology and Markets*, ed. G. Chichilnisky, Columbia University, AMS, 1999, 110pp.

## Upcoming Volumes

The Arnol'dfest (Proceedings of the Fields Institute Conference in Honour of the 60th Birthday of Vladimir I. Arnol'd), eds. E. Bierstone, B. Khesin, A. Khovanskii and J. Marsden

Topics in Game Theory and Mathematical Economics, ed. M. Wooders

Proceedings of the Workshop on Analysis and Simulation of Communication Networks, eds. P. Glynn, D. McDonald, R. Srinivasan, and S. Turner.

## Scientific Preprint Series

The Institute research visitors are encouraged to submit their work to our Preprint Series. Copies of these preprints are made available in the James Stewart Library and on the Institute's web-site ([www.fields.utoronto.ca/preprints/FI](http://www.fields.utoronto.ca/preprints/FI)).

### General Scientific Preprints 1998

Dawson, D. A., The Fields Institute; "Large Deviations for the Fleming-Viot process with neutral mutation and selection".

Langford, William F., The Fields Institute and University of Guelph; "Interactions of Andronov-Hopf and Bogdanov-Takens Bifurcations" and "Pattern Formation in Annular Convection".

Lawniczak, Anna, University of Guelph; "Probabilistic Lattice Models of Collective Motion and Aggregation; from individual to collective dynamics".

Lu, Steven Shin-Yi, University of Waterloo; "Logarithmic Jet Bundles and Applications".

Mei, Zhen, The Fields Institute; "Forced Symmetry-Breaking via Boundary Conditions".

### General Scientific Preprints 1999

Rybnikov, K., The Fields Institute & Queen's University; "On Traces of  $d$ -stresses in the Skeletons of Lower Dimensions of  $d$ -manifolds".

### Probability Theory Preprints 1998

Atar, Rami, The Fields Institute and Dupuis, Paul; "Large Deviations and Queueing Networks: Methods for Rate Function Identification".

Konig, Wolfgang, Fields Institute and Technische Universität Berlin; "An embedding for the Kesten-Spitzer random walk in random scenery".

Salisbury, Thomas S., The Fields Institute and York University; "Non-Degenerate Conditionings of the Exit Measures of Super Brownian Motion" and "On the Conditioned Exit Measures of Super Brownian Motion".

## Probability Theory Preprints 1999

Atar, Rami, The Fields Institute; “A differential game with constrained dynamics and viscosity solutions of a related HJB equation”.

Athreya, Siva, The Fields Institute; “Monotonicity Property for a Class of Semilinear Partial Differential Equations” and “On a Singular Semilinear Elliptic Boundary Value Problem and the Boundary Harnack Principle”.

Athreya, Siva, The Fields Institute and Roger Tribe, University of Warwick; “Stochastic PDEs Using Moment Uniqueness for a Class of One-Dimensional Duality”.

Borgs, Christian, Microsoft Research; “Mean-field Lattice Trees”.

Fuks, Henryk, The Fields Institute and University of Guelph; “Exact Results for Deterministic Cellular Automata Traffic Models”.

Lawniczak, Anna, The Fields Institute and University of Guelph; “From Reactive Lattice Gas Automaton Rules to Its Partial Differential Equations”.

Lawniczak, Anna, The Fields Institute and University of Guelph; “Performance of data networks with random links”.

Madras, Neal, The Fields Institute and York University; “A Pattern Theorem for Lattice Clusters”.

Slade, Gordon, The Fields Institute and McMaster University; “Lattice trees, percolation and super-Brownian motion”.

Slade, Gordon, The Fields Institute and McMaster University; “The Scaling Limit of the Incipient Infinite Cluster in High-Dimensional Percolation I. Critical Exponents”.

Slade, Gordon, The Fields Institute and McMaster University; “The Scaling Limit of the Incipient Infinite Cluster in High-Dimensional Percolation II. Integrated Super-Brownian Excursion”.

Volkov, Stanislav, The Fields Institute; “Branching random walk in random environment: fully quenched case”.

Volkov, Stanislav, The Fields Institute; “Vertex-reinforced random walk on arbitrary graphs”.

Voroney, Jon-Paul; Lawniczak, Anna, The Fields Institute and University of Guelph; “Construction, Mathematical Description and Coding of Reactive Lattice-Gas Cellular Automaton”.

# FINANCIAL OVERVIEW

The 1998-99 year was successful financially from two points of view. The Institute was able to set aside the deferred revenue to complete its program for the current academic year, to generate a surplus on its operations for the year, and to reduce its accumulated deficit. In addition, for the first time we are able to present the results of the Institute's financial performance in the traditional format of a balance sheet and a statement of income and expenditures.

During the course of the year the Institute increased its revenues, thanks to an enhanced grant from NSERC and to the OMET curriculum revision project. At the same time, the Institute managed its expenditures carefully. In particular, the deferred revenue figure of \$218,205 on the balance sheet represents funds set aside to cover commitments to be made during the balance of the 1998-99 thematic program year from funds received during the 1998-99 fiscal year. The operating surplus of \$169,127 during the fiscal year was sufficient to eliminate the major part of the Institute's accumulated deficit.

The factors driving these most satisfying financial results are expected to continue into the current fiscal year.

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Note: The following Auditor's Report is an electronic copy of the original document.

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## AUDITORS' REPORT

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To the Board of Directors of the  
**Fields Institute for Research in Mathematical Sciences**

We have audited the balance sheet of the **Fields Institute for Research in Mathematical Sciences** as at March 31, 1999 and the statement of operations and deficit for the year then ended. These financial statements are the responsibility of the Institute's management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with generally accepted auditing standards. Those standards require that we plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In our opinion, these financial statements present fairly, in all material respects, the financial position of the Institute as at March 31, 1999 and the results of its operations and the changes in its financial position for the year then ended in accordance with generally accepted accounting principles.

Toronto, Canada,  
May 10, 1999.

*Ernst & Young LLP*  
Chartered Accountants

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**Fields Institute for Research in Mathematical Sciences**

**BALANCE SHEET**

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As at March 31

	<b>1999</b>	<b>1998</b>
	\$	\$
<b>ASSETS</b>		
Due from University of Toronto <i>[note 3]</i>	<b>112,451</b>	-
Accounts receivable	<b>178,884</b>	174,293
GST rebates receivable	<b>43,533</b>	114,886
	<b>334,868</b>	289,179
<b>LIABILITIES AND DEFICIT</b>		
<b>Liabilities</b>		
Due to University of Toronto <i>[note 3]</i>	-	319,103
Accounts payable and accrued liabilities	<b>169,318</b>	60,927
Deferred revenue	<b>218,205</b>	130,906
<b>Total liabilities</b>	<b>387,523</b>	510,936
<b>Deficit</b>	<b>(52,655)</b>	<b>(221,757)</b>
	<b>334,868</b>	289,179

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*See accompanying notes*



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**Fields Institute for Research in Mathematical Sciences**

**STATEMENT OF OPERATIONS AND DEFICIT**

As at March 31

	<b>1999</b>	<b>1998</b>
	\$	\$
<b>INCOME</b> [schedule]		
Ontario Ministry of Education and Training		
Operating grant	<b>1,000,000</b>	1,000,000
Mathematics Curriculum Project grant	<b>309,600</b>	--
Natural Sciences and Engineering Research Council of Canada	<b>792,701</b>	829,841
University partners	<b>143,500</b>	141,000
Publications	<b>41,908</b>	58,866
Other external grants	<b>85,472</b>	88,020
Miscellaneous	<b>16,048</b>	8,802
	<b>2,389,229</b>	2,126,529
<b>EXPENSES</b> [schedule]		
Salaries and benefits [scientific and support staff	<b>897,828</b>	769,926
Employee research and administrative	<b>32,921</b>	35,049
Visitors travel	<b>593,939</b>	683,428
Communications	<b>27,430</b>	39,115
Printed material and publishing	<b>40,139</b>	40,592
Equipment rental, maintenance and lease	<b>56,730</b>	71,948
General and office supplies	<b>37,124</b>	34,169
Rent and services [note 3]	<b>525,346</b>	549,908
Professional services	<b>5,537</b>	10,000
Interest charge [note 3]	<b>3,133</b>	63,928
	<b>2,220,127</b>	2,298,063
<b>Net surplus(deficit) for the year</b>	<b>169,102</b>	(171,534)
Deficit, beginning of year	<b>(221,757)</b>	(50,223)
<b>Deficit, end of year</b>	<b>(52,655)</b>	(221,757)

*See accompanying notes*



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**Fields Institute for Research in Mathematical Sciences**

**NOTES TO FINANCIAL STATEMENTS**

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March 31, 1999

**1. PURPOSE OF THE ORGANIZATION**

The Fields Institute for Research in Mathematical Sciences [the "Institute"] was founded in 1991 with federal and provincial funding. The Institute was incorporated as a corporation without share capital under the Corporations Act (Ontario) by Letters Patent dated September 28, 1994. The Institute is a centre for world class research in the mathematical sciences. The Institute's mandate includes programs devoted to leading-edge research in the mathematical sciences; advancement in mathematics education; enhanced graduate and post-doctoral training opportunities; and developing partnerships with industry to encourage technology transfer.

**2. SIGNIFICANT ACCOUNTING POLICIES**

These financial statements have been prepared by management in accordance with generally accepted accounting principles. The most significant accounting policies are as follows:

**Revenue recognition**

The Institute follows the deferral method of accounting for contributions. Unrestricted contributions are recognized as revenue when received or receivable if the amount to be received can be reasonably estimated and collection is reasonably assured. Contributions externally restricted are deferred and recognized as revenue in the year in which the related expenses are recognized.

**Contributed materials and services**

The value of contributed materials and services is not reflected in these financial statements.

**3. RELATIONSHIP WITH UNIVERSITY OF TORONTO**

The University of Toronto [the "University"] is the host site for the Institute and has agreed to provide certain services and access to certain facilities as described in the Agreement between the Governing Council of the University and the Institute dated October 1, 1995. The Agreement is for a term of 25 years.

The University processes all transactions for the Institute. Interest is earned or paid on the average monthly cash balance held by the University.

The University has licensed the Institute to use the premises located at 222 College Street, Toronto and charges the Institute an annual "Block Fee" of \$500,000 for the cost of this space and services listed in the Agreement.



**NOTES TO FINANCIAL STATEMENTS**

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March 31, 1999

**4. STATEMENT OF CHANGES IN FINANCIAL POSITION**

A separate statement of changes in financial position has not been presented, since in the opinion of management, the information it would contain is readily apparent from the other financial statements.

**5. YEAR 2000 ISSUE**

The Year 2000 Issue arises because many computerized systems use two digits rather than four to identify a year. Date-sensitive systems may recognize the year 2000 as 1900 or some other date, resulting in errors when information using year 2000 dates is processed. In addition, similar problems may arise in some systems which use certain dates in 1999 to represent something other than a date. The effects of the Year 2000 Issue may be experienced before, on, or after January 1, 2000, and, if not addressed, the impact on operations and financial reporting may range from minor errors to significant systems failure which could affect an entity's ability to conduct normal business operations. It is not possible to be certain that all aspects of the Year 2000 Issue affecting the Institute, including those related to the efforts of customers, suppliers or other third parties, will be fully resolved.

mathematics

“...concerned with the study of number, quantity, shape , and space, and their inter-relationships, applications, generalizations and abstractions.”

Collins Dictionary of Mathematics  
E.J. Borowski & J.M. Borwein