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

Since its inception in 1991, the Fields Institute has served as a focal point for collaborative research in the mathematical sciences and has had exceptional impact on how mathematics is perceived and taught around the world.

Under the directorship of Dr. Donald Dawson, the Fields Institute contributes to leading-edge research in the mathematical sciences, facilitates the advancement of mathematics education, provides enhanced graduate and postdoctoral training opportunities and develops partnership with industry in order to encourage technology transfer.

Our research activities bring together prominent mathematicians from around the globe for periods of intensive collaboration on topics of current importance. Thematic programs are selected by an independent group of leading Canadian and international mathematicians, known as the Scientific Advisory Panel.

World-renowned members of the mathematics community deliver distinguished lectures on their award-winning research. Unique courses, seminars, and workshops offer graduate students and postdoctoral fellows access to world leaders and allow private sector mathematical scientists access to the latest developments in their respective fields. Last year alone, the Institute hosted over 1,100 visitors from 41 countries to partake in research in pure and applied mathematics, statistics, computer science, engineering, biology, theoretical physics, economics, finance, telecommunications, and medicine.

Named for Canadian mathematician John Charles Fields (1863-1932) whose will established the International Medal for Outstanding Discoveries in Mathematics, now known as the Fields Medal, the Fields Institute flourishes in Toronto’s urban center. We provide office space for 78 visitors, a 100-seat lecture theatre, a seminar room, an atrium conducive to informal gatherings, and the James Stewart Library.

Funding is provided by the Ontario Ministry of Training, Colleges and Universities (MTCU), and the Natural Sciences and Engineering Research Council of Canada (NSERC). Our five Principal Sponsoring Universities: McMaster University, the University of Toronto, the University of Waterloo, the University of Western Ontario and York University; and our 6 Affiliates: 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 Atlantic Association for Research in Mathematical Sciences, consisting of Dalhousie University, Memorial University of Newfoundland and the University of New Brunswick, provide a strong scientific base.
It seems only yesterday I was preparing the message from the Chair for inclusion in the 1999 Annual Report. Gone by very quickly is another year, marked by successful Institute activity and continued maturation of its staff and programming. Just as clearly defined are the challenges in front of us.

The Institute’s scientific activity – programmes, workshops and seminars – is surveyed in the reports from the Director and the Deputy Director. It is quite evident that the focus of this activity has been on the mark, and that the content is of high quality, attracting participation and interest from across Canada and around the world. The “Legacy of John Charles Fields” Symposium, organized by the Institute, brought together nine Fields medallists who launched mathematics into the 21st century. During the course of the year the capabilities of our administrative staff have grown and solidified significantly. The arrangements with the University of Toronto, our host university, whereby the Institute has access to the University’s premises and various forms of administrative support were reviewed and extended for another three-year period. I believe it fair to say that the relationship with our host, after the first few years of settling in, is now working smoothly.

One challenge facing the Institute, a challenge that in reality represents an important opportunity for it and all member universities, is the need for the Institute to generate and support mathematical activity “off-site”. Fulfilment of the Institute’s mandate requires Fields to generate programs, workshops and research in locations throughout the country. Working with representatives of our member universities, it is our intention to meet that challenge.

The financial results for the year reflect our greatly improved capability for controlling, tracking, and managing the monetary consequences of Fields’ activity. The Statement of Operations and Deficit shows that again, for the 1999-2000 fiscal year, the Institute operated with a net surplus. The amount of that surplus was sufficient to eliminate the accumulated past deficit and to provide on our balance sheet a modest surplus. The fact that the Institute is able to conduct its normal operations out of current income, coupled with the existence of an accumulated surplus, enables the Institute to face the future in an enviable position. We are able to consider expanding in both depth and range the Institute’s activity, and to access new sources of revenue from the private sector. The Institute provides a valuable message from the Chair of the Board
service to the communities of Ontario and indeed all of Canada, and it is our intention build future activity on that understanding.

As I am sure most of those reading this report will know, Don Dawson, our Director, chose to relinquish his responsibilities as of June 30th. Forty years ago, Don and I had a common summer employer, although we did not meet, as we were one summer apart. Our paths crossed again for the last four years at the Institute, where Don has provided outstanding and invaluable leadership. More than any other single factor, Don as Director, has pushed the Institute into the top ranks of mathematical institutes worldwide. Your Board of Directors accepted Don’s decision with reluctance, but we respect his decision, and as they return to Ottawa we wish him and Betty many more years of future success and happiness.

The Institute is in the midst of the search for Don’s replacement. The task is not made simple by the requirements of the position: outstanding scientific reputation, proven administrative skills, the ability to manage and to develop relationships with funding and potential funding agencies, and the diplomacy needed to work with varied membership communities. While the search is making progress, the Institute will not have Don’s replacement in position by July 1st. To bridge the period until the new Director is identified and in place, the Board of Directors has appointed our Deputy Director, Bradd Hart, to serve as Acting Director. Bradd joined our staff last fall, and has taken a very active and involved role in all aspects of the Institute. I am confident that Bradd and the support he will receive from Board members during this interim period will see us through the transition.

In addition to thanking Don and Bradd, I want to express the appreciation of the Board for all members of the staff, especially Becky Sappong who part way through the year grabbed the reins of the Program Manager role and has given it a strong and well-defined shape, and Kelvin Wannamaker, Executive Assistant, who has supported the Director and Deputy Director by carrying out the myriad of tasks relating to our external involvements. Going beyond our own people, the Institute once again owes a great debt of gratitude to the support it receives from the Ministry of Training, Colleges and Universities (MTCU) and the Natural Sciences and Engineering Research Council of Canada (NSERC), our founding agencies, and to our member’s universities.

John Gardner
MESSAGE FROM THE DIRECTOR

UNESCO and the International Mathematical Union designated the year 2000 as World Mathematical Year (WMY) with special events organized around the globe to highlight the importance and role of mathematics. In the proclamation of the WMY, the following objectives were stated:

- the determination of great mathematical challenges of the 21st century,
- the promulgation of mathematics, both pure and applied, as one of the main keys for development, and
- the recognition of the systematic presence of mathematics in the information society.

Over the past year the Fields Institute experienced an unprecedented intensity of activity very much in the spirit of the WMY goals. These activities demonstrate the international nature of mathematics and its importance for many areas of science, commerce and technology.

At the international level the year began with the First Canada-China Mathematics Congress in August which was supported by NSERC and the three Canadian mathematics institutes. NSERC President Tom Brzustowski led a delegation of 60 Canadian mathematicians on a week-long scientific meeting at Tsinghua University in Beijing with nearly 100 Chinese mathematicians and students. This provided an unprecedented opportunity to develop new research relationships and to plan for an increased level of scientific exchanges between Canada and China. Another international initiative was the Conference on the Future of Mathematical Communications held at the beginning of December at MSRI, Berkeley with the co-sponsorship of Fields, CRM, PIMS, MSRI and the IMU’s Committee on Electronic Information and Communication (CEIC).

The 1999-2000 program year included two on-site Thematic Programs and the support of over 25 on-site and off-site conferences, workshops and special lectures in the General Scientific Program. The program on Causal Interpretation and Identification of Conditional Independence Structures brought to Fields researchers at the nexus of statistics, artificial intelligence and philosophy for a non-stop series of seminars, short courses and research collaboration. The program on Graph Theory and Combinatorial Optimization has featured six large workshops, three mini-symposia and four graduate courses and this program will continue during the summer of 2000 at the Pacific Institute for Mathematical Sciences. Much of the scientific leadership for the activities in this program was provided by the Department of Combinatorics and Optimization at the University of Waterloo and the Department of Computer Science of the University of Toronto. Three special highlights of the past year were the
Coxeter Lecture Series of Professor László Lovász (Microsoft) who lectured on Geometric Representations of Graphs, Paul Seymour (Princeton University) who lectured on Graph Minors and the CRM-Fields Prize Lecture of Professor Stephen Cook of the Department of Computer Science at the University of Toronto who lectured on The Achievements and Accomplishments of Computational Complexity.

A new dimension of activity at the Fields Institute has been launched over the past year in its role as one of the administrative and scientific support centres of the MITACS (Mathematics of Information Technology and Complex Systems) network. MITACS, which was created as a joint initiative of the three Canadian institutes (CRM, Fields and PIMS), received funding by the National Centres of Excellence program (NCE) to begin operation in 1999. This national network currently supports twenty-three research projects involving researchers from 22 Canadian universities in partnership with over 60 industrial affiliates, all integrated into a pan-Canadian research community. The principal activities of the Fields-Mitacs Industrial Program include: administrative and scientific support for 7 projects from the Biomedical, Finance/Trading, Manufacturing and Information Technology sectors, networking and theme meetings, identification of new research topics and creation of seed projects, support for the development of industrial mathematics graduate programs at partner universities, and workshops and short courses in industrial mathematics. Among the 1999-2000 Fields-MITACS highlights were theme meetings in the Finance and Trading, Biomedical and Information Technology Themes and a Workshop on Data Analysis for Commercial and Industrial Applications which was co-sponsored by the Fields Institute, Nortel Networks, MITACS and the Nortel Institute.

To complement these activities and to foster communication in the broader mathematical sciences community, the Fields Institute and MITACS also sponsored three series of interdisciplinary seminars: Seminars in Commercial-Industrial Mathematics, Seminars in Financial Mathematics and Seminars in Applications of Statistical Science.

Last but not least, the Symposium on the Legacy of John Charles Fields (June 7-9, 2000) together with the MITACS AGM and Math 2000 in Hamilton served as a centerpiece of the Canadian Celebration of WMY. The Symposium was an historical event with lectures by nine Fields Medalists as well as two lectures on the life and work of John Charles Fields and the impact of the Fields Medal on 20th century mathematics.

The successes of the past year have been made possible by the contributions of many individuals and organizations. The Board of Directors and the Corporate Members provide sound financial management and ensure that the programs of the Institute respond to the needs and priorities of the many stakeholders. The high quality of the Institute’s scientific programs owe much to the guidance of our Scientific Advisory Panel. Special thanks are due to the organizing and scientific committees of the Causal Identification and Interpretation of Conditional Independence Structures Program and the Special Year on Graph Theory and Combinatorial Optimization for their important contributions to the scientific activities of the institute. Organizers and participants alike expressed their thanks to the wonderful Fields staff for making everything work smoothly even at the most hectic times. Finally I would like to give special thanks to Bradd Hart who took over as Deputy Director in September 1999 for the innovative ideas, energy and organizational skills, which he has brought to the Institute.
On a personal note, my term as Director of Fields will end June 30, 2000. The past four years have been exciting and challenging. Much has happened during this period including the NSERC Reallocations and funding competition for the institutes, the contract with the Ministry of Education to write the Curriculum Policy Document for Mathematics, the creation of MITACS and the new international initiatives mentioned above. These achievements have given Fields a unique role in basic science, mathematics education and technology transfer as well as a solid foundation for future development. At the national level, an important ingredient for the continued development of Canadian mathematical sciences is the close collaboration, which has developed among the three Canadian Institutes. This development owes much to the efforts and leadership of the CRM Directors, Luc Vinet and Jacques Hurtubise, and to the PIMS Director, Nassif Ghoussoub. The financial support provided to the Fields Institute by NSERC and MTCU, the sponsoring and affiliate universities, and the corporate members provides Ontario and Canada with an invaluable resource for the development of excellence in research and synergy in the mathematical sciences. I must give personal thanks to John Gardner, who as Chairman of the Board of Directors provided the support and guidance, which contributed greatly to the well-being of the Institute.

Don Dawson
MESSAGE FROM THE DEPUTY DIRECTOR

It has been an exciting year at the Fields Institute, my first as Deputy Director. Don and John have touched on most aspects of the Institute in their messages so I would just like to comment on only a few things in which I was personally involved and thank some of the many people who make the Institute the success it is.

The financial shape of the Institute has never been better and the management structure has been revamped so the challenge for the coming years is to maintain the high level of activity both on and off-site. Discussion has begun on this, primarily with our sponsoring universities, and I believe this challenge can be met.

An enormous growth area for the Fields Institute is our commercial-industrial program. In addition to the seven MITACS projects that we coordinate, which provide the program with a solid base, we have seen an explosion of activity: the Nortel-sponsored workshop “Data Analysis for Commercial and Industrial Applications”, a seminar series on data mining, the Institute’s participation in the creation of a chapter of the Global Association of Risk Professionals, several short courses on financial mathematics, the formation of the Ontario Center for Energy Finance, a discussion with several partners on the creation of a professional mathematics program and a variety of spin-off and incubation projects. A longer discussion of this exciting area appears later on in this annual report.

The Institute remains firmly committed to its program in mathematics education. This is grounded by the Mathematics Education Forum, which meets monthly. This year, the Forum focused on the implementation of the new Ontario secondary school mathematics curriculum and the demand for qualified mathematics teachers at all levels. The activities of this tremendously dedicated group is outlined in the Mathematics Education section of this report.

I would like to take this opportunity to thank Becky Sappong and Uma Gupta for their efforts in making the Institute the smooth running operation it is. Ben Schwartz for his energy and enthusiasm for the commercial-industrial program, and Eric Muller for his tireless work on the Mathematics Education Forum. Finally, I want to both thank and send good wishes to Don Dawson as he leaves the Fields Institute; his dedication to Fields and the quality of the work he has done here sets a very high standard for future directors.

Bradd Hart
THEMATIC PROGRAMS

Special Year on Graph Theory and Combinatorial Optimization
August 1999 - May 2000

Scientific and Organizing Committee:

N. Alon (Tel Aviv University)
R. Anstee (University of British Columbia)
J. Cheriyan (University of Waterloo)
D. Corneil (University of Toronto)
B. Cunningham (University of Waterloo)
A. Gupta (Simon Fraser University)
P. Haxell (University of Waterloo)
P. Hell (Simon Fraser University)
M. Molloy (University of Toronto)
B. Pulleyblank, (IBM Watson Research)
B. Richter (Waterloo University)
K. Seyffarth (University of Calgary)
L. Tuncel (University of Waterloo)

The two themes of “approximation algorithms” and “polyhedral and semidefinite methods”, which were both the subject of graduate courses and the three workshops in the fall, enriched each other. Many of the best new approximation algorithms use methods from linear and semidefinite optimization.

Perhaps the most important foundational result in combinatorial optimization obtained during the past year, is the existence of a combinatorial, strongly polynomial algorithm for submodular function minimization. This was found independently by Schrijver and by Iwata, Fleischer and Fujishige. All of these researchers participated in the special year, with two of them in residence at Fields for the fall. Improvements, extensions, and applications of their results were a very hot topic. Although this work was most emphasized at the third workshop on extensions of matroids, the methods used are related to polyhedra, so there were also connections with the second workshop (where Schrijver described his work).

The Coxeter Lecturer for the fall term was László Lovász, Microsoft Research. His series was titled “Geometric Representations of Graphs”. Many deep results in graph theory, related to connectivity, planarity, linkless embeddability, and other important ideas are related to the existence of representations that map the vertices to points in a finite dimensional space with some restrictions. Lovasz’s lectures covered an amazing amount of very elegant mathematics. There were many connections with the themes of the special year. Most important, existence of many of these representations can be decided by methods from optimization, especially linear and semidefinite optimization.

After Christmas the attention turned to graph theory. There were three workshops, namely Graph Minors and Topological Graph Theory, Probabilistic Graph Theory, and Structured Families of Graphs. In order to respond quickly to new developments in the field, three mini-symposia were also held during
the term. Each of these mini-workshops was organized by a resident postdoctoral fellow and was built around two internationally known experts in the field.

One of the major breakthroughs in graph theory in the last twenty years has been the work done by Neil Robertson and Paul Seymour in developing the concept of tree-width of a graph and settling Wagner’s Conjecture (for any infinite set of graphs one of them is a minor of another). Paul Seymour presented an overview of this and other recent results in the Coxeter Lecture Series. The concept of tree-width has also led to some important results in computational complexity. For example it has been shown that if a problem is expressible in Second Order Monadic Logic, then there is a linear time algorithm for the problem on graphs with bounded tree-width. Thus the structural composition reflected by the bounded tree-width can be algorithmically exploited for a wide range of problems. Recently, considerable work has been done in trying to enlarge the type of structural compositions while still retaining the efficient computation. One of the most promising such compositions is that of clique-width of a graph; again, any problem expressible in Second Order Monadic Logic can be solved in linear time on graphs with bounded clique-width. In fact, any graph of bounded tree-width is also of bounded clique-width, but the converse is not true. During the term, the study of the clique-width of a graph received considerable attention from many of the participants.

**Workshops**

**Approximation Algorithms for Hard Problems in Combinatorial Optimization**

September 26-October 1, 1999

Organizing Committee: J. Cheriyan (University of Waterloo), M. Goemans (University of Louvain and MIT), D. Shmoys (Cornell University)

The invited speakers at the workshop were established researchers (Feige, Garg, Karger, Kleinberg, Queyranne, Rabani, Rao, Ravi, Vazirani, Vempala, Williamson, Zwick) and promising junior researchers (Charikar, Chekuri, Chudak, Guha, Jain, Skutella, Sviridenko). The main topics from the workshop were:

1) metric uncapacitated facility location and metric k-medians - fast algorithms that give approximation guarantees of ≤6 - this is the result of intense research over the last 2-3 years; [Jain, Charikar, Guha, Chudak];

2) achieving improved approximation guarantees via Lagrangian relaxation for metric k-medians, and k-MST (k-minimum spanning tree); [Charikar, Guha, Garg, Williamson];

3) metrics and cuts - low distortion L1 embedding of the metric of a planar graph, and related topics [Rao, Kleinberg];

4) graph bisection - via dynamic programming together with the Leighton-Rao algorithm for sparsest cuts [Feige];

5) PTAS (polynomial time approximation scheme) for problems in scheduling [Karger, Chekuri].

External funding was gratefully received from the US NSF International Programs Division.
Polyhedral and Semidefinite Programming Methods in Combinatorial Optimization
November 1-6, 1999

Organizing Committee: W. H. Cunningham (University of Waterloo), W. R. Pulleyblank (IBM Watson Research, New York), A. Schrijver (CWI, Amsterdam), L. Tuncel (University of Waterloo)

Polyhedral methods have been extremely useful in solving many combinatorial optimization problems. The combinatorial structure of polyhedra is amongst the most intriguing subjects in combinatorial optimization. Good comprehension of the structure of the facets of polyhedra usually leads to efficient practical algorithms for related combinatorial optimization problem. Such comprehension also carries the potential of cross-fertilization with many areas of mathematics. Since 1960’s polyhedral methods have had a central role to play in both the theory and practice of combinatorial optimization. Since the early 1990’s, a new technique, semidefinite programming, has been applied to combinatorial optimization problems. Semidefinite programming problem is the problem of optimizing a linear function of matrix variables subject to finitely many linear inequalities and the positive semidefiniteness condition on the matrix variable. On certain problems, such as maximum cut, and maximum stable set and even a graph colouring problem semidefinite programming techniques yield important, new results.

The workshop brought together a group of experts in either or both areas. The presentations included material, which greatly improved the current understanding of the relationships between these two areas and how these two methods complement each other in producing more efficient methods for solving combinatorial optimization problems.

Several talks focused on the new and fundamental results in the Theory of Scheduling. This is an area with very close ties to practical applications yet with many fundamental and exciting problems in discrete mathematics. Polyhedral and Semidefinite Programming methods again emerged as the most exciting approaches in the Theory of Scheduling. Talks on very fundamental issues, such as the very famous Perfect Graph Conjecture (a beautiful subject at the crossroads of Graph Theory and Theory of Polyhedra), and the notion of the intersection of Gomory-Chvatal and Lovász-Schrijver closures of polyhedra and convex sets tied in very well with the other main activities at Fields.

The reach of the workshop was so wide that at the applied end, there was the very practical talk of Bixby and the financial applications talk of Bertsimas, which mentioned quite often things like the stock market and the Black-Scholes formula. Even these very practical talks tied in very nicely with the rest. In Bertsimas’ talk many fundamental inequalities using the partial order induced by the cone of symmetric positive semidefinite matrices came up. Bixby’s talk showed where the state-of-the-art is in the implementation of polyhedral method in practice.

External funding was gratefully received from the US Office of Naval Research.

Matroids, Matching and Extensions
December 6-11, 1999

Organizing Committee: W. H. Cunningham (University of Waterloo), A. Frank (Eötvös University, Budapest), J.F. Geelen (University of Waterloo), A. Sebő (CNRS, Grenoble)

This workshop culminated the fall term on combinatorial optimization, and was held at the University of Waterloo, December 6-11. Funding support was gratefully received from the Faculty of Mathematics at the University of Waterloo.
In view of the major new results on algorithms for submodular function minimization, there was a great deal of time devoted to these methods and their implications, for example, to algorithms for submodular flow problems. Fleischer, Fujishige, Iwata, and McCormick gave talks on these topics.

There has also been a lot of recent excitement on the solutions of the Polya problem, and the matching lattice problem, both of which relate to the theory of perfect matchings. McCuaig, Murty, and Thomas gave talks on these subjects.

Other talks were on Geelen's revolutionary algebraic matching algorithm, and further applications of his methods, graph factor problems (Hell), the matroid structure (Oxley, Gerards, Johnson), ideal clutters (Guenin, Sebo), and some other generalizations of matroids or matchings (Jackson, Frank, Murota).

Graph Minors and Topological Graph Theory
January 17-22, 2000

Organizer: Bruce Richter (University of Waterloo)
Invited Lecturer: Carsten Thomassen (Technical Mathematical Institute, University of Denmark)

Over the past decade, Carsten Thomassen has been a leader in proving structural results about colourings of graphs embedded in surfaces. This began with his beautiful proof that planar graphs are 5-choosable (if sets of 5 colours are assigned to each vertex, possibly a different set for each vertex, then there is a proper colouring of the graph so that each vertex is coloured using one of the colours in its assigned set). But he has opened the door also to many interesting questions concerning graphs embedded in more complicated surfaces — e.g., every such surface has only finitely many 6-critical graphs (i.e., graphs that minimally require 6 colours to properly colour them). Along the way he has given short proofs of Grötzch's Theorem and extended it to higher genus embeddings. As well, his detailed study of surfaces led him to a deep topological characterization of the sphere, something that surprised the topologists. This work has tied together topological graph theory (important in the Graph Minors Project, which proves the graph theoretical assertion that there is no infinite antichain in the minor order on the set of finite graphs) with more traditional graph theory (in this case, colourings of graphs). These are deep and important connections.

One of the open sessions was led by Joan Hutchinson and André Kündgen, who spoke about various kinds of geometric graphs, such as visibility graphs (graphs made up of geometric objects in some Euclidean space (lines or rectangles in the plane, boxes in three dimensions), with adjacency determined by whether the two objects can see each other (usually in a straight line in the direction of a coordinate axis)). Related are the so-called “Art Gallery Theorems”, in which, typically, one is given an “Art Gallery” (usually a non-convex polygon in the plane) and one asks how many guards are required so that every wall (side of the polygon) is watched by some guard at all times. If there are also interior walls, the problem was solved, but in one case an unusually difficult analysis was used. After some discussion among a small number of participants, it seems that a much more satisfactory analysis of that case was made.

More significantly, another open session was devoted to crossing numbers of graphs. It is well understood that computing the crossing number of a graph is quite hard. One participant pointed out that it was easy to prove that crossing-critical graphs (i.e., graphs for which every proper subgraph has strictly smaller crossing number) have bounded tree-width (that is, they have a nice decomposition into “small” pieces which are glued together in a tree-like way). He went on to suggest that an even more refined conjecture can be
made on the basis of our experience, namely that they have bounded path-width (the small pieces can be glued together in a path-like way, not just a tree-like way). Petr Hlineny, of the Fields Institute, has since proved this conjecture. It is an important advance in the theory of crossing numbers and suggests that; at least in a broad sense, graphs that are crossing-critical and have crossing number \( k \) (there are infinitely many of them for \( k > 1 \)) can still be understood.

**Probabilistic Graph Theory**  
February 14-19, 2000

Scientific and Organizing Committee: J. Cheriyan (University of Waterloo), A. Frieze (Carnegie Mellon University), M. Molloy (University of Toronto), J. Spinrad (Vanderbilt University), L. Stewart (University of Alberta).

The workshop was well attended by many of the international leaders in this field. Much time was set aside for collaborations, and this led to a number of new results. For example, Achlioptas, Frieze and Sorkin initiated an impressive project towards bounding the threshold for a random instance of 3-SAT to become unsatisfiable. This project was completed shortly after the end of the workshop. Also, during the workshop and the following week, Achlioptas and Molloy proved that the appearance of the giant component in a random graph could be improved significantly if one can choose between two random edges at each time step.

**Structured Families of Graphs**  
May 8-13, 2000

Organizing Committee: D. Corneil (University of Toronto), J Spinrad (Vanderbilt University), L. Stewart (University of Alberta)

Motivated by the diverse applications of graph theory and the search for efficient algorithms for these applications, considerable work has been done in identifying and studying restricted families of graphs. Hopefully, such restrictions will capture the graphs affiliated with the application and will result in efficient algorithms for such graph classes. The workshop was built around 10 plenary lectures given by experts from 6 different countries. The workshop participants were also invited to present contributed talks. A special session was organized for graduate students to present their theses results and to obtain guidance from internationally recognized experts.

Financial support of the workshop was gratefully received from the Connaught Fund and the Faculty of Arts and Science at the University of Toronto.
Mini-Symposia

Triple Systems and their Generalizations
February 28-March 3, 2000
Organizer: E. Mendelsohn (University of Toronto), L. Moura (University of Toronto)
Speakers: C.C. Lindner (Auburn University), R. Mathon (University of Toronto), A. Rosa (McMaster University)

Extremal Graph Theory
March 13-16, 2000
Organizer: A. Kündgen (University of Toronto)
Speakers: Z. Füredi (University of Illinois, Urbana-Champaign and Rényi Institute, Budapest) and M. Simonovits (Rényi Institute, Budapest and University of Memphis)

Geometric Representations of Graphs
April 11-14, 2000
Organizer: P. Hlinený, The Fields Institute
Speakers: J. Kratochvíl (Charles University, Czech Republic), S. Whitesides (McGill University)

Graduate Courses

Approximation Algorithms
J. Cheriyan (University of Waterloo)

Polyhedral and Semidefinite Methods in Combinatorial Optimization
L. Tuncel (University of Waterloo)

Topological Graph Theory
R. B. Richter (University of Waterloo)

The Probabilistic Method
M. Molloy (University of Toronto)

Coxeter Lecture Series

Geometric Representations of Graphs
November 1-3, 1999
by László Lovász (Yale University and Microsoft Research)

Graph Minors
January 17-19, 2000
by Paul Seymour (Princeton University)
Mini-Program on Causal Interpretation and Identification of Conditional Independence Structures
September to November 1999

Organizing Committee:
H. Massam (University of Virginia)
D. Tritchler (University of Toronto)

Scientific Committee:
P. Dawid (University College, London)
S. Lauritzen (Aalborg University)
M. Perlman (University of Washington)

This research program brought together a group of eminent researchers in the subdisciplines of Statistics, Probability, Algebra, Artificial Intelligence, and some areas of applications with the intent to improve on the current understanding of the basic structures of Highly Structured Stochastic Systems (HSSS) models. The two graduate courses trained students in statistics, and researchers in areas of applications, in newly developed techniques. It was important that graduate students be exposed to a variety of disciplines involved in the study of HSSS so that they could take a multidisciplinary approach in their research. Two short courses that were applicable to business, medical or social sciences, introduced already developed software to non-specialists who are in decision-making positions.

The program included five seminars that were successful in bringing different groups of researchers together. Other conferences on this topic are affiliated with particular professional organizations and thus tend to attract researchers within one specific discipline, to the exclusion of those from other areas. The reputation of the Fields Institute is sufficiently large that the meeting was able to attract researchers looking at closely related causal questions in fields as diverse as epidemiology, biostatistics, computer science, philosophy and mathematical statistics. Another highly beneficial aspect of the working environment provided by the Institute was that it was possible to arrange the seminars so that it combined structured presentations and unstructured informal discussions. This allowed a common theme for the workshop to develop, which was then followed up in more intense interactions among several smaller groups working on specific subproblems.
Seminars

Causal Interpretation of Graphical Models
September 27-October 8, 1999

Organizers: P. Dawid (University College, London), G. Shafer (Rutgers University)

Graphical models have been traditionally seen as ways of describing and manipulating probabilistic conditional independence. However, they are often given informal causal interpretations, and there now exist mathematical ways of making these precise and manipulating them. This research seminar extended the understanding of these methods, and explored the scope of graphical modelling as a tool for causal inference and analysis. Attention was also focus on the nature of the relationship between causal interpretations and conditional independence properties of graphical representations, the two main themes of the overall program.

Conditional Independence Structures
September 27-October 15, 1999

Organizers: F. Matúš (Academy of Science of Czech Republic), M. Studený (Academy of Science of Czech Republic)

The precise description of conditional independence structures and the one-to-one correspondence of these structures with their visual or algebraic representation are fundamental to the development and implementation of algorithms for estimation, testing, etc. This description can be done using different types of graphs but also using non-graphical tools based on information theory such as imsets or matroids. The concept of conditional independence often occurs also in miscellaneous non-probabilistic calculi for dealing with uncertainty in artificial intelligence.

The purpose of the seminar is to first recall the relatively simple mathematical tools needed for the axiomatic or graphical characterization of conditional independence structures. Then, researchers focused on the open problems in this area mentioned in the original proposal. This type of research can be viewed as the research for the precise mathematical description of all conditional independence structures, using both graphs and non-graphical methods.

Relating Causal Structure to Conditional Independence Structure
October 11-29, 1999

Organizers: T. Richardson (University of Warwick), P. Spirtes (Carnegie Mellon University)

The first week of the seminar consisted of a workshop on the topic of Relating Causal Structure to Conditional Independence Structure. The main goal of the workshop was to foster interaction and communication between researchers studying the theory of causal inference, researchers working on statistical questions relating to the estimation of conditional independence models, and applied statisticians involved in the analysis of real data. The workshop succeeded in achieving this goal: there were 24 participants from 8 different countries. The following topics were central themes in the workshop:

- assumptions relating causal dependence and statistical dependence
- methods for efficiently estimating causal effects
- causal model selection procedures
- causal hypotheses that arise in applied statistical work
During the second and third week of the seminar a smaller number of participants worked on specific technical questions. Initial steps were taken towards extending reversible jump MCMC algorithms for undirected graphs to directed graphs. Several estimation strategies for causal models were investigated, and in the light of some new results obtained, a new direction for research was proposed which will be the subject of future investigation. The assumptions underlying standard methods for sensitivity analysis in causal inference were investigated and newly developed graphical model search techniques were applied to a large data set. Future meetings are already planned to carry forward these joint research projects.

Learning Causal Models
November 2-12, 1999

Organizers: D. Heckerman (Microsoft Research), S. Lauritzen (Aalborg University)

Seminar 1 and 2 introduced connections between causal interpretations of graphs and their conditional independence properties. This seminar discussed how these connections could be applied to the problem of learning about causal relations from data.

We considered both Bayesian and asymptotic approaches, with an emphasis on the former. We related causal interpretations to commonly used assumptions used for the selection of graph structure such as parameter independence, parameter modularity, and marginal likelihood equivalence. In addition, we addressed difficulties in scoring and searching over graphical models with latent variables, compare model selection to model averaging techniques, and discuss assumptions under which “counterfactual” information can be learned.

Algebraic Methods in Graphical Markov Models
October 25 - November 12, 1999

Organizers: S. Andersson (Indiana University), G. Letac (Université Paul Sabatier), H. Massam (University of Virginia), M. Perlman (University of Washington)

The past ten to fifteen years have seen the growth of a vibrant, influential, and highly cross-disciplinary international network of scientists whose common denominator is the study and development of algebraic methods in distribution theory and statistics.

The aim of this meeting was to bring together researchers with this common interest. In the first intensive week of the meeting twenty participants presented their point of view and some current work. Among the many interrelated topics were distributions on manifolds, in particular on spheres, group invariant distributions, Riesz distributions, distributions related to graphical models, in particular the covariance selection models, moments of the Wishart distribution, extensions of the class of Wishart distributions and their properties, generalized inverse Gaussian distributions, the hyper Wishart distributions, and enrichments of classical prior distributions in the Bayesian context. A wide range of mathematical tools are being used, studied, and developed in this context: general and concrete group representations, multivariate Laplace transforms, Jordan algebras, homogeneous cones, measures and invariance, graph theory, manifolds, Markov Chain Monte-Carlo (MCMC) simulations, and many more.

The classical Wishart distribution occurs as the distribution of the estimator of the covariance matrix in multivariate analysis of variance (MANOVA). The hyper Wishart distribution was defined in 1993 only in the context of graphical models given by an undirected graph. The independently and re-
cently developed extended class of Wishart distributions turned out to be, somewhat surprisingly, connected with graph theory. This interesting overlap has been clarified, investigated and further generalized during the workshop. Graphical models use graphs to represent restrictions of multivariate dependencies in a visual and computationally efficient manner. The extensions of the class of Wishart distributions can be used as the distribution and/or an approximation of the distribution of the estimator of the covariance under these graphically induced restrictions. The analysis used in graphical models also applies to the analysis of models in other areas such as econometrics and psychometrics (structural equations), computer science (artificial intelligence) informatics (influence diagrams and Bayesian networks). Thus, research in these fields needs further work in the mathematical and statistical theory of the extended classes of Wishart distributions.

Furthermore, the analysis of many models related to graphs relies on the Bayesian approach, which in turn uses MCMC simulations based on enriched classes of prior distributions from the class of exponential families. The workshop brought together this simulation approach and the analytic approach represented by several research areas. The intensive work environment during the workshop has lead to new collaboration among the investigators. Several researchers are now working toward a coherent approach to their different areas of research, as well as extensions of their theories. This workshop has thus opened up new, fascinating avenues of research, clarified several overlaps, and inspired new ideas and collaborative research in the area of algebraic methods in statistics.

Courses

Graphical Markov Models
S. Andersson (Indiana University)

Linear Structural Equations and Graphical Models
J. Koster (Erasmus University)

Short Courses

Diagnosing and Planning with Bayesian Networks and Influence Diagrams (A Practical Guide)
U. Kjærulff (Aalborg University), K. Olesen (Aalborg University)

Graphical Markov Models: Their Role in Statistical Analysis of Data Generating Processes
D. Cox (Nuffield College, Oxford), N. Wermuth (ZUMA - Center for Survey Research, Mannheim)

Sewall Wright Lecture Series

The Mathematics of Cause and Effect
October 25-26, 1999
by Judea Pearl (University of California)

The Language of Causality
November 4 & 9, 1999
by Glenn Shafer (Rutgers University)
CRM-FIELDS PRIZE

The Centre de recherches mathématiques and the Fields Institute jointly established the CRM-Fields prize in 1994 with the goal of recognizing exceptional work in the mathematical sciences. The recipient is chosen by the Advisory Committee of the CRM together with the Scientific Advisory Panel of the Fields Institute. The main selection criterion is outstanding contribution to the advancement of research.

Stephen Cook
1999 Recipient

The fifth annual Centre de recherches mathématiques/Fields Institute Prize was awarded to Dr. Cook in recognition of his pioneering research in computational complexity and its connections with logic, as well as parallel computation and the semantics of programming languages. Dr. Cook gave a lecture on “The Achievements and Challenges of Computational Complexity” which focused on the importance, plausibility, and difficulty of the conjecture that the “P” and “NP” classes in computational complexity are not equal. Cited, in particular, was his famous 1971 paper, “The Complexity of Theorem Proving Procedures,” which introduced the now-standard notion of NP-completeness. The complexity class P (for polynomial-time) consists of those computational problems that can be solved by an efficient algorithm. By comparison, problems in the class NP (for nondeterministic polynomial-time) might not be able to be solved efficiently, but proposed solutions can at least be verified efficiently.

Many NP problems, such as the satisfiability of logical formulas, are so ubiquitous that an efficient means of solving them would provide an efficient way to solve any NP problem. These problems are called NP-complete; if an efficient algorithm for solving any of these problems were found, it would prove that P and NP were in fact one and the same. Other NP problems, such as integer factorization, might be somewhat easier to solve but still not easy enough to qualify for membership in P. Integer factorization is notable because many present-day cryptographic schemes rely on the difficulty of factoring large integers for their security. An efficient algorithm for factoring integers would cause enormous breaches of security in applications from data encryption to electronic financial transactions to the privacy of our UNIX passwords. Dr. Cook gave examples of how researchers attempt to pin down the exact computational complexity of solving various problems. Exhibiting and analyzing explicit algorithms for solving a problem (or for reducing it to a previously solved problem) will show that the problem belongs to a certain complexity class. In contrast, proving that no possible algorithm of a certain complexity can solve a problem relies on more indirect and subtle techniques.

Stephen Cook was born in Buffalo, New York. He received his B.Sc. Degree from the University of Michigan in 1961 and his M.Sc. 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 at Berkeley. He joined the Department of Computer Science at the University of Toronto in 1970 as an Associate Professor and was promoted to a Professor in 1975.
Israel Michael Sigal  
2000 Recipient

Professor Sigal is a mathematical physicist that brings the problems of physics and chemistry, especially the deep problems of the nature of matter, to mathematics. As such, he works in the part of mathematics concerned with modeling basic physical phenomena. While the models themselves can be deceptively simple, it turns out to be extraordinarily difficult to establish that they do in fact replicate experimentally known phenomena, an effort that has motivated the development of a large part of deep mathematical analysis.

Sigal’s work goes to the very heart of quantum theory, that is, the long-term behaviour of particles under interactions. His work has primarily centered on the Schroedinger equation, which is at the heart of mathematical models of atoms and molecules. In the 1920’s, Schroedinger formulated what has become the standard equation for quantum mechanics. It created a whole new field of mathematics dealing with the behaviour of the Schroedinger operators; that is with the general behaviour of the solutions. For fifty years, one major unsolvable problem remained. The theorem established through a series of papers by Sigal and his former postdoctoral student, Soffer, provided the first completely rigorous solution.

In recent years Professor Sigal has made groundbreaking contributions to the theory of interaction between light and matter, known as Quantum Electrodynamics. A basic set of equations to explain the interaction between electrons and photons was first proposed by Physics Nobel laureates Feynmann, Schwiger and Tomonaga around 1950. Their work created a need for a precise, consistent mathematical description of the theory and for over 40 years this task seemed to be beyond reach. Sigal’s recent contribution is the first convincing attempt to provide consistent mathematical description of Quantum Electrodynamics and represent a revolutionary approach to the subject.

Professor Sigal is currently a professor at the University of Toronto. He received his PhD from Tel Aviv University. His work has been rewarded by many honours; including several invited lectures to the International Congress on Mathematical Physics and the International Congress of Mathematics, as well as the editorship of two of the most respected journals in the field, Reviews in Mathematical Physics and Duke Mathematical Journal. He is also a Fellow of the Royal Society of Canada and received the John L. Synge Award as the outstanding Canadian mathematician in 1993.
International Conference and Workshop on Valuation Theory  
July 26 - August 11, 1999  
Held at the University of Saskatchewan  
Organizing Committee: F.-V. Kuhlmann (University of Saskatchewan), S. Kuhlmann (University of Saskatchewan), M. Marshall (University of Saskatchewan), D. Haskell (College of the Holy Cross), H. Schoutens (Wesleyan University)

Séminaire de Mathématiques Supérieures on "Integrable Systems: from Classical to Quantum"  
July 26 - August 6, 1999  
Held at the University of Montréal  
Organizing Committee: A. Daigneault (Université de Montréal), Dr. J. Hamad (Concordia University and Université de Montréal), P. Winternitz (Université de Montréal), S. Lessard (Université de Montréal), W. Miller, (University of Minnesota-Minneapolis), A. Polychronakos (Ioannina University, Greece and Uppsala University, Sweden), G. Sabidussi (Université de Montréal)

The First China-Canada Congress of Mathematical Sciences  
August 23-27, 1999  
Held at Tsinghua University in Beijing, China  
Organizing Committee: D. Cai (Director, Math Institute, Tsinghua University), K.C. Chang (President, Chinese Mathematical Society), L. Peng (Director, Math Institute, Beijing University), X.-W. Zhou (Director, Math Institute, Nankai University), D. Dawson (Director, Fields Institute), N. Ghoussoub (Director, Pacific Institute for Math. Sci.), S. Halperin (Program Leader, MITACS), R. Kane (President, Canadian Mathematical Society), L. Vinet (Director, Centre de recherches mathématiques)

Operateur Theory on the Prairies  
August 27-28, 1999  
Held at the University of Regina  
Organizing Committee: J. Erlijman (University of Regina), D. Farenick (University of Regina)

The CRM-Fi Prize Lecture by Stephen Cook  
"The Achievements and Challenges of Computational Complexity"  
September 30, 1999  
Held at the Fields Institute

Trends in Differential Equations and Dynamical Systems  
October 22-24, 2000  
Held at Memorial University of Newfoundland  
Organizing Committee: H. Brunner (Memorial University), E. Goodaire (Memorial University), X. Zou (Memorial University)

Ontario Algebraic Combinatorics Workshop IV  
November 27, 1999  
Held at the Fields Institute  
Organizing Committee: N. Bergeron (York University), S. van Willigenburg (York University), D. Wagner (University of Waterloo)

The Future of Mathematical Communication @ 1999  
December 1-5, 1999  
Held at the Mathematical Sciences Research Institute in Berkeley, California  
Scientific Committee: F. Bergeron (CRM), J.
Borwein, (PIMS & CEIC), Joe Buhler (MSRI), B. Hart (Fields Institute), M. Groetschel (IMU & CEIC)

Sponsored with CRM, PIMS, IMU and the MSRI

**Canadian Mathematical Society Winter Meeting 1999**
December 11-13, 1999

Held at the Université de Montréal

**Data Analysis for Commercial and Industrial Applications**
February 1 - 4, 2000

Held at the Fields Institute

Co-sponsored with Mitacs, Nortel Networks and the Nortel Institute

**The 2000 Nerenberg Lecture by Mark W. Tilden** (Robotics Physicist, Los Alamos National Laboratory)
March 17, 2000

Held at the University of Western Ontario

**Quantum Physics Centennial Symposium**
March 17-19, 2000

Held at the University of Saskatchewan

Organizing Committee: J. Brooke (University of Saskatchewan), C. Rangacharyulu (University of Saskatchewan), T. Steele (University of Saskatchewan), K. Taylor (University of Saskatchewan), J. Weil (University of Saskatchewan)

**The Sixth Great Lakes K-theory Conference**
March 25-26, 2000

Held at the Fields Institute

Organizing Committee: E.M. Friedlander (Northwestern University), D. Grayson, (University of Illinois at Urbana-Champaign), J.F. Jardine (University of Western Ontario), M. Kolster (McMaster University)

**Probability Theory and Modern Finance: A Professional Introduction**
April 11-12 and June 28-29, 2000

Held at the Fields Institute

Instructors: T. Salisbury (York University), M.A. Milevsky (York University)

April 13, 2000

Held at the Fields Institute

Organizing Committee: A. Menezes (Centre for Applied Cryptographic Research (CACR)), S. Shannon (CACR and SVI Consulting)

**Meeting the Demands for Qualified Teachers of Mathematics**
April 27, 2000

Held at the Fields Institute

Organizers: E. Barbeau (University of Toronto), B. Hart (Fields Institute), J. Ip (Toronto District School Board), J. Kezys (Mohawk College), E. Muller (Brock University), P. Rogers (York University), G. Roulet (Queen’s University), W. Whiteley (York University)

**A Workshop in Honour of Stephen A. Cook**
April 28 - 29, 2000

Held at the Fields Institute

Organizer: A. Borodin (University of Toronto)

Held at the University of Western Ontario.

Organizers: SONAD: R. Corless (University of Western Ontario) and ECCAD: M. Giesbrecht (University of Western Ontario), G. Labahn (University of Waterloo)

Quantitative Methods For Credit Risk Management May 15-16, 2000

Held at the Fields Institute

Instructor: D. Rosen (Algorithmics Inc.)

Year 2000 Statistical Society of Canada Annual Meeting June 4-7, 2000

Held in Ottawa, Ontario

28th Canadian Annual Symposium on Operator Algebras June 4-8, 2000

Organizers: M. -D. Choi (University of Toronto), G. Elliott (University of Toronto, The Fields Institute, and University of Copenhagen)

Co-sponsored with the University of Toronto

Canadian Undergraduate Mathematics Conference June 6-10, 2000

Held at McMaster University and the Fields Institute

World Mathematical Year 2000 Symposium - The Legacy of John Charles Fields June 7-9, 2000

Held at the Royal Ontario Museum

Scientific Program Committee: J. Arthur (University of Toronto), J. Chadam (University of Pittsburgh), D. Dawson (The Fields Institute), G. Elliott (University of Toronto, University of Copenhagen and Fields Institute), P. Fillmore (Dalhousie University), N. Ghousoub (University of British Columbia and PIMS) B. Hart (McMaster University and Fields Institute), B. Hodgson (Laval University) J. Hurtubise (CRM and McGill University), J. Marsden, (California Institute of Technology), C. Morawetz, (Courant Institute), C. Riehm, (McMaster University), L. Vinet, (McGill University)

MATH 2000 – the Canadian Mathematical Society Summer Meeting and the Canadian Applied and Industrial Mathematics Society Annual Meeting June 10-13, 2000

Held at McMaster University

DASF II - Data Analysis and Statistical Foundations June 15 - 16, 2000

Held at the Fields Institute

Sponsored by the Department of Statistics, University of Toronto
FIELDS COMMERCIAL AND INDUSTRIAL MATHEMATICS PROGRAM

The Commercial and Industrial Mathematics program (CIM) acts as a conduit connecting the mathematics community and businesses that benefit from research in the mathematical sciences. The CIM program seeks to transfer results in the mathematical sciences to the business community and transmit the mathematical needs of the business community to the mathematics community. This year the MITACS initiative has played a central role in the CIM program.

Activities of the 1999-2000 CIM program comprised:
- Administering 7 MITACS projects;
- Coordinating 3 MITACS theme and several project meetings;
- Developing and organizing a joint career exhibition for mathematical scientists for the CMS and MITACS;
- Organizing 4 seminar series;
- Organizing 2 workshops;
- Organizing 2 short courses;
- Formation of a research centre; and
- Incubating a new firm.

Fields-MITACS Projects

The MITACS federal Network of Centres of Excellence has brought to the Institute exciting university/industry collaborative research projects in key sectors of the economy: the biomedical, commercial/industrial, information technology, manufacturing, and trading/finance sectors. MITACS provides mathematical models, software tools, and highly qualified personnel to assist Canadian firms. This year the CIM program administered 7 Ontario based MITACS projects in 4 key sectors of the economy:

**Biomedical Sector**
1. Statistical Modeling and Analysis of Complex Traits in Human Population  
   Project Leader: Dr. Shelley Bull (University of Toronto)
2. Mathematical and Computer Modeling of Epidemics with Public Health Applications  
   Project Leader: Dr. John Hsieh (University of Toronto)

**Information Technology Sector**
3. Pattern Storage, Retrieval and Recognition Using Neural Networks  
   Project Leader: Dr. Sue Ann Campbell (University of Waterloo)
4. Complex Adaptive Networks for Computing and Communication (Cancomm)  
   Project Leader: Dr. Mihail Devetsikiotis (Carleton University)
5. Applied Cryptography  
   Project Leader: Dr. Scott Vanstone and Dr. Doug Stinson (University of Waterloo)

**Manufacturing Sector**
   Project Leader: Dr. Harry Ruda (University of Toronto)

**Finance and Trading Sector**
   Project Leader: Dr. Luis Seco (University of Toronto)
**MITACS Site Visit**

In September 1999, a delegation of 35 distinguished visitors from the Royal Swedish Academy of Engineering Sciences, led by his majesty King Carl XVI Gustaf visited the Fields Institute. We hosted the delegation as part of a site visit to MITACS, a national centre of excellence. Don Dawson, director of the Fields Institute (then acting MITACS program leader), greeted the delegates, while Arvind Gupta, the current MITACS program leader, delivered a MITACS research overview.

**MITACS Theme Meetings**

The Institute hosted the theme meeting of the MITACS finance sector in May 1999 and the MITACS biomedical, as well as the information technology theme meetings in November 1999. Investigators from around the country associated with MITACS research in each of these themes met to exchange ideas and discuss future research directions.

**CMS-MITACS Career Exhibition**

On June 7, 2000, the Fields Institute organized a career exhibition, which was developed for the CMS. The career exhibition was integrated with the MITACS Annual General Meeting and was held at the Joseph L. Rotman School of Management, University of Toronto. Over 200 students, graduate and undergraduate, as well as many postdoctoral fellows, and other investigators attended the event, along with representatives from 14 companies including:

- AD OPT
- Air Canada
- Algorithmics Inc.
- Certicom
- Generation 5
- IBM Centre for Advanced Studies
- Nortel Networks
- Powerex
- Sigma Analysis and Management
- Tm Bioscience corporation
- Vision Smart
- Waterloo Maple
- Zero Knowledge Systems Inc.
- 724 Solutions
Seminar Series

This year the CIM program offered four seminar series, which were all co-sponsored by the MITACS network and each series focused on applications of mathematics in industry. (For details please see pages 30-31).

Financial Mathematics

The Financial mathematics seminar series continues to experience enormous popularity with the academic and the business community. Of course, it is the active participation of both communities that accounts for the success of this seminar series. The Fields Institute was privileged to host many distinguished speakers.

Data Analysis, Mining and Warehousing

In the fall of 1999 a mini seminar series on data analysis, mining and warehousing was held. Professor Irwin Pressman, School of Mathematics and Statistics, Carleton University, organized these highly informative series of lectures.

Applied Statistics

The purpose of this joint seminar series with the Department of Statistics at the University of Toronto, was to provide a forum for presentation of wide-ranging applications of statistics and probability to problems of current scientific interest, in diverse fields from the medical, physical, engineering, mathematical, and social sciences.

GARP Lectures

New this year to the Institute were a series of lectures coordinated by a newly formed Toronto chapter of the Global Association of Risk Professionals (GARP), a not-for-profit, independent organization of financial risk management practitioners and researchers. The GARP lectures expose mathematical problems and solutions in the emerging profession of financial risk analysis and management.

CIM Workshops

CIM workshops provided for a dialogue between industrial and university researchers on common mathematical topics of interest.

Data Analysis for Commercial & Industrial Applications

On February 1-4, 1999, over 80 international research, private sector and student participants gathered together at the Institute for a workshop on Data Analysis for Commercial & Industrial Applications. The Fields Institute and the Nortel Institute for Telecommunications (of the University of Toronto) jointly
organized the workshop. Dr. Claudine Simson, V.P., Disruptive Technology, Network and Business Solutions, Nortel Networks, gave the opening address.

The aim of the workshop, which was sponsored by Nortel Networks and MITACS, was to bridge leading-edge mathematical techniques with commercial and industrial applications of data analysis, and to present open problems which are motivated by commercial and industrial needs.

An international group of speakers presented ongoing research and issued provoking data analysis challenges in order to share mathematical results and ideas on current data analysis methodologies. Various communities from across the mathematics, statistics, physics, biophysics, computer science, telecommunications, and engineering were represented. Participants included faculty and students from various Canadian, U.S., European universities, as well as representatives from Nortel Networks, the IBM Centre for Advanced Studies, Bank of Montreal, Dofasco Inc., and Generation 5.

**Fifth CACR Information Security Workshop**

In April 2000, the Institute hosted the Fifth CACR Information Security Workshop. Professor Scott Vanstone, executive director, and Doug Stinson, managing director of the highly successful University of Waterloo’s Centre for Applied Cryptographic Research are both project leaders for the MITACS project ‘Applied Cryptography’. This workshop focused on wireless e-business: security and applications. Topics covered included challenges (constraints) and opportunities of developing and deploying secure applications for the wireless and mobile environment. The speakers for the workshop included representatives from various companies such as Certicom, 724 Solutions, Research in Motion, Bank of Montreal, and Entrust Technologies.

**Professional Short-Courses**

The CIM program organized two professional courses, which were held at the Institute and were sponsored by MITACS. These courses were targeted to professionals seeking a better understanding of the modern mathematical techniques applied in the financial industry.

**Probability Theory and Modern Finance**

Professor Thomas Salisbury and Professor Moshe Milevsky combined forces to teach a highly successful two-day course on ‘Probability Theory and Modern Finance’.

**Quantitative Methods for Credit Risk Management**

Dr. Dan Rosen, Director of Research, Algorithmics Inc., taught a popular course on ‘Quantitative Methods for Credit Risk Management’. The students of the Mathematical Finance Program, University of Toronto, attended Dr. Rosen’s course. The students had a first hand opportunity to study a “hot topic” in mathematical finance alongside a diverse group of risk management professionals.
Incubation

*Sigma Financial Analysis and Management*

Housed within and incubated by the Institute is a new firm called Sigma, a financial analysis and management firm, founded by David Rudd, director of products, BetterMarkets.com and Professor Luis Seco, University of Toronto. Sigma is now both a corporate member of the Fields Institute and a MITACS industrial partner to Professor Seco’s MITACS project.

*Ontario Centre for Energy Finance*

Driven by the combined efforts of a team drawn from the MITACS project ‘The Mathematics of Financial Risk’, McMaster University, of Toronto, York University and the Fields Institute, the Ontario Centre for Energy Finance (OCEF) was created. OCEF is designed to study and develop risk management models for the electricity industry. Led by Professor Luis Seco, OCEF is mandated to develop “equitable” risk management models to help build liquid, efficient and transparent financial markets. The formation of the centre is an alliance between the Institute and a private sector partner, BetterMarkets.com; an on-line commodity trading centre providing businesses the opportunity to trade risk in a real time, high speed, secure environment.
Financial Mathematics Seminar Series

Organizing Committee: P. Boyle (University of Waterloo), M. Crouhy (Canadian Imperial Bank of Commerce), D. Dawson (Fields Institute), R. Dembo (Algorithmics Inc.), A. Levin (Bank of Montreal), T. McCurdy (University of Toronto), T. Salisbury (York University), S. Turnbull (Canadian Imperial Bank of Commerce).

Sponsored by MiTACS

September 29, 1999
Stanislav Uryasev, University of Florida
"Optimization of Conditional Value-at-Risk"

Dan Rosen, Algorithmics Incorporated
"An Integrated Market and Credit Risk Portfolio Model"

October 27, 1999
Dilip Madan, University of Maryland
"Purely Discontinuous Asset Price Processes"
José Luis Farah, ITAM (Mexico)
"Moments in Financial Markets"

November 24, 1999
Lane Hughston, University of Texas at Austin and King’s College, London
"Stochastic Differential Geometry, Financial Modelling, and Arbitrage-Free Pricing"
Xin Guo, IBM research division and University of Alberta
"What is Missing in Black-Scholes?"

January 26, 2000
Jérôme Detemple, Boston University School of Management and CIRANO
"A Monte Carlo Method for Optimal Portfolios"

February 23, 2000
Steven E Shreve, Carnegie Melon University
"Options on a Traded Account"

Ken Vetzal, University of Waterloo
"Valuing the Option Features of Segregated Funds"

March 29, 2000
George Papanicolaou, Stanford University
"Mean Reverting Stochastic Volatility"

Thomas Wilson, Swiss Re, New Markets
"Credit Portfolio, Risk Measurement and Management: Issues and Practical Solutions"

April 26, 2000
Eduardo Schwartz, University of California at Los Angeles
"Rational Pricing of Internet Companies"

Eric Reiner, UBS AG at Warburg Dillon Read
"Volatility Rules and Implied Processes"

May 31, 2000
Emanuel Derman, Goldman, Sachs and Co.
"Fear and Greed in Volatility Markets"

Melanie Cao, Queen’s University and Jason Wei, University of Toronto at Scarborough
"Pricing Weather Derivatives: an Equilibrium Approach"
Applications of Statistical Science Seminar Series

The series provided a forum for presentation of wide-ranging applications of statistics and probability to problems of current scientific interest, in diverse fields from the medical, physical, engineering, mathematical, and social sciences.

Organizers: N. Reid (University of Toronto), D. Dawson (Fields Institute)

Sponsored with the Statistics Department, University of Toronto and MITACS

October 5th 1999
Steffen Lauritzen, Aalborg University
“Probabilistic Networks and Expert Systems”

December 7, 1999
Eugene Fiume, University of Toronto
“Probabilistic and Statistical Techniques in Realistic Computer Graphics”

February 1, 2000
Murad Taqqu, Boston University
“Scaling Phenomena in Telecommunications”

March 7, 2000
Joseph F. Fletcher, University of Toronto
“Two Timing: Politics and Response Latencies in a Bilingual Survey”

April 4, 2000
James Stafford, University of Toronto
“Smoothing techniques for surveys”

Data Analysis, Mining and Warehousing Seminar Series

Sponsored by MITACS

October 25, 1999
Andrei Broder, AltaVista
“Document Resemblance and Related Issues”

November 5, 1999
David Heckerman, Microsoft Research
“Causal Discovery from Non-Experimental Data”

November 8, 1999
Murray Campbell, IBM T.J. Watson Research Center
“Data Mining”

November 22, 1999
Chen Wei Xu, Bank of Montreal
“An Overview of Data Mining and its Challenges in a Banking Environment”

Global Association of Risk Professionals (GARP) Seminar Series

May 18, 2000
Michel Crouhy, Canadian Imperial Bank of Commerce
“Internal rating systems and credit risk modelling for capital allocation”

June 21, 2000
Brian Ranson, Bank of Montreal
“The evolution of credit risk management in global financial institutions”
THE LEGACY OF JOHN CHARLES FIELDS: 
A Symposium for World Mathematical Year 2000

The International Mathematical Union declared the year 2000 to be World Mathematical Year and in response the Fields Institute organized a symposium, "The Legacy of John Charles Fields" – a three-day meeting, June 7-9, featuring nine lectures by Fields medallists, two historical lectures, a panel discussion on the future of mathematics and a well-attended banquet. As well as a tribute to J. C. Fields, the symposium was part of a larger celebration of Canadian mathematics, preceded by the first MITACS Annual General Meeting and followed by Math 2000 at McMaster University.

Sir Michael Atiyah gave the opening lecture of the symposium to a packed J.J.R. MacLeod Auditorium on the University of Toronto campus with over 400 people in attendance. His talk, entitled "Mathematics in the 20th Century" proved to be quite provocative and the topic of much debate throughout the three days.

On the evening of June 7th, a panel discussion on the future of mathematics was moderated by Richard Kane and consisted of Jim Arthur, Michael Atiyah, Alan Baker, Richard Borcherds, Tim Gowers, Lisa Jeffery, Cathleen Morawetz, Stephen Smale and Efim Zelmanov. The discussion was lively and topics ranged from the scale to which physics would continue to inform mathematics to the degree to which computers will one day be able to "do" mathematics.

On June 8th and 9th, the symposium moved to the Royal Ontario Museum and nearly 300 people were in attendance. The following is a list of speakers:

Tom Archibald (Acadia)                J.C. Fields: the research ideal in mathematics and in the organization of science
Alan Baker (Cambridge)               Diophantine Analysis and Transcendence Theory: the way forward
Richard Borcherds (Berkeley)         Automorphic Forms
Alain Connes (IHES)                  Renormalization and the Riemann-Hilbert Problem
Timothy Gowers (Cambridge)           Combinatorics in the Service of Mathematics
Vaughan Jones (Berkeley)             Planar Algebras: between dimensions two, three and infinity
Maxim Kontsevich, (IHES)             Limits of Complex Structures
John Milnor (Stony Brook)            Complex Systems: the role of mathematics
Michael Monastyrsky (ITEP)           Trends in Modern Mathematics and the Fields Medals
Stephen Smale (Hong Kong)            The Mathematics of Theories of Learning and Intelligence
On the evening of the 8th, a banquet was held at Hart House. Sir Michael Atiyah spoke on “Mathematics as Architecture”. The banquet was sponsored by the Bank of Montreal, the Bank of Nova Scotia, Bettermarkets.com, the Canadian Imperial Bank of Commerce, Centre de recherches mathématiques, McMaster University, Nortel Networks, the Pacific Institute for the Mathematical Sciences, the Royal Bank, Toronto-Dominion Bank, the University of Toronto and the University of Waterloo. The meeting was also sponsored by the Canadian Mathematical Society, the Canadian Applied and Industrial Mathematics Society, the Connaught Foundation, MITACS and the Royal Society of Canada.

The symposium was organized by J. Arthur (Toronto), J. Chadam (Pittsburgh), D. Dawson (Fields), George Elliott (Chair, Toronto), P. Fillmore (Dalhousie), N. Ghoussoub (UBC), B. Hart (McMaster), B. Hodgson (Laval), J. Hurtubise (McGill), J. Marsden (Caltech), C. Morawetz (Courant) C. Riehm (McMaster), L. Vinet (McGill).

All eleven lectures and the panel discussion were filmed and the Fields Institute intends to make these lectures available both over the Internet and on video. Check the Institute’s Webpage: www.fields.utoronto.ca, for more information.
Field's Mathematics Education Forum

The Fields Institute Mathematics Education Forum (the Forum) promotes discussion of issues in mathematics education at all levels with special emphasis on education in the Province of Ontario, but with relevance to national and international education issues. The Forum membership comes from a wide spectrum of education and non-education sectors including high school teachers, educators from colleges, faculties of education and universities, representatives from school boards and interested industry members. The Fields Institute serves as the host of the Forum, but does not determine the agenda or the conclusions of the Forum. It is the goal of the Forum to consider objectively new ideas and diverse views in mathematics education, to facilitate consensus and to promote the enhancement of mathematics education in Ontario and Canada.

This year the Forum was co-chaired by Bradd Hart and Eric Muller. Members of the Steering Committee were Lynda Colgan, Shirley Dalrymple, Gordon Dowsley, Myrna Ingalls and David Zimmer.

The Forum met on six Saturdays during the year and continued to be active on two fronts, the Ontario Secondary Mathematics Curriculum and the mathematics education of teachers at all school levels. On three occasions members of the Forum were presented with information regarding the new Grade 11 and 12 mathematics courses and they were able to provide informal input into the number, content and approach of these courses. Last year, the Forum struck a Task Force to make recommendations regarding the preparation of mathematics teachers at all levels and to look into the projected shortage of secondary mathematics teachers in Ontario. During the summer months a project under Walter Whiteley at York University developed a set of materials for distribution to school and university students for the promotion of teaching mathematics as a career.

On Thursday April 27, 2000, the Task Force organized and ran a one-day meeting entitled "Meeting the demand for qualified teachers of mathematics" to which mathematics educators from a variety of organizations and interest groups were invited. Attendance was limited to about forty people. The scientific program included short presentations on demographics and special mathematics education programs, and involved participants in Working Groups. The Forum is using the outcomes of this meeting to develop strategies to address (i) the mathematics preparation of Primary/Junior and Junior/Intermediate teachers, and (ii) the looming shortage of Intermediate/Senior mathematics teachers, and the role of mathematics departments in encouraging and preparing them.

At its second last meeting of the year, the Forum struck two new Task Forces. Both of these will be responding to the new situation in Ontario, which arises from the elimination of OAC in 2003 and the implementation of a new mathematics curriculum. The first Task Force will work on the transition from the new Grade 12 mathematics courses to college and university mathematics, including admissions requirements. The second Task Force will be looking for resources for the new Grade 12 course entitled Mathematics of Data Management.

Preliminary reports of the Teacher Education work by the Fields Mathematics Education Forum were presented by Eric Muller and Walter Whiteley at Joint Meetings of the MAA and AMS in Washington DC (January 2000) and by Bradd Hart and Eric Muller at Joint Meetings of Canadian Mathematical Societies in Hamilton (June 2000).
SIMMER

SIMMER (Society for Investigating Mathematical Mind-Expanding Recreations) is a monthly meeting jointly funded by the Fields Institute and the Department of Mathematics at the University of Toronto and held at the Fields Institute. Each SIMMER meeting features a keynote presentation by an invited speaker, along with a lively discussion of related recreational mathematics problems and ideas. All this takes place over the course of a light supper and refreshments.

October 1999
Ed Barbeau
"Pell’s Equation"

November 1999
Mark Spivakovsky
“A Mathematical ‘Hodgepodge”

January 2000
Craig G. Fraser
“Problems and Puzzles in Babylonian Mathematics”

February 2000
Bruce A. Cload
“Escher and You”

March 2000
Cynthia Church and Randall Pyke
“Dancing with Fractals: The Chaos Game (with Music!)”

May 2000
Greg Martin and Emmanuel Knafo
“‘Split ‘P’ Soup’: Partaking of Number Theory”

Throughout this year the meetings have gained great popularity with Toronto and surrounding area high school mathematics teachers, with the average number of attendees being 40 and reaching as high as 75. We have also had bright high school students joining their teachers for some of these sessions.
MEMBERS OF THE CORPORATION

2000-2001

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2000-2001

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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 seven 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. John Chadam's research interests are mainly in Non-Linear Partial Differential Equations and their applications to Materials Sciences, Geochemistry, Petroleum Engineering, Finance, etc. He has been affiliated in many capacities with the Fields Institute since its inception. He was Scientific Director from 1994 to 1996. Since then he has been Chair of the Mathematics Department at the University of Pittsburgh.

Donald Dawson received his Honours B.Sc. in Mathematics and Physics from McGill University in 1958 and his doctorate from MIT in 1963. He has taught at both McGill University and Carleton University and is currently Professor Emeritus and Distinguished Research Professor at Carleton and Adjunct Professor at McGill. He has been a codirector of the Carleton-Ottawa Laboratory for Research in Statistics and Probability since 1982 and served as Director of the Fields Institute from 1996-2000. 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 communications. He is a Fellow of the Royal Society of Canada. He has been honored with an invitation to speak at the 1990 International Congress of Mathematicians in Kyoto and as a 1999/2000 Aisenstadt Chair Lecturer, 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 mathematical theories of many body systems at low temperatures.

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 (1962-66) and Duncan Distinguished Professor of Mathematics, Purdue University (1985-88). Dr. Friedman is currently a Pro-
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.

Andrew Granville completed his undergraduate education at Trinity College, Cambridge, and received his PhD from Queen’s University, Kingston. He is the David C. Barrow Professor of Mathematics at the University of Georgia. He has also held visiting positions at Purkyne University, the Institute for Advanced Study, Isaac Newton Institute, Universidad Autonoma, Madrid, University of Michigan and University of Leiden. He was an invited speaker at the International Congress of Mathematicians in 1994. In that same year he was awarded a Presidential Faculty Fellowship by President Clinton, in 1995 the Hasse Prize by the MAA, and in 1999 the Ribenboim Prize in Number Theory. He is an editor of about a dozen journals including the Journal of Number Theory, Mathematics of Computation and the Electronic Journal of Combinatorics.

Bradd Hart is the Deputy Director of the Fields Institute. He received his undergraduate education at the University of Waterloo and received his PhD from McGill University in 1987. He is now a professor in the Mathematics and Statistics Department of McMaster University. He was awarded an NSERC University Research Fellowship in 1989. Before joining McMaster, he was a postdoctoral fellow at the University of California at Berkeley. He has had visiting positions at the Mathematical Sciences Research Institute in Berkeley and the University of Illinois at Chicago. In 1996-97, he was an organizer of a thematic year in Algebraic Model Theory at the Fields Institute. He gave a plenary lecture at the European Logic Colloquium in 1998 and is a member of the Executive Council of the Association of Symbolic Logic.

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 Moore 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. She is Vice President for Programs for the Society for Industrial and Applied Mathematics.

Nicholas Pippenger received his PhD from MIT in 1974. He was a research scientist for IBM Research until 1989 and has been a professor at the University of British Columbia since 1988. He is a Fellow of the Royal Society of Canada, an ACM Fellow, an IEEE Fellow and spoke at the International Congress of Mathematicians in 1986. He was an IBM Fellow from 1987 to 1989 and was awarded a Killam fellowship in 1991. His main area of research is theoretical computer science and complexity theory.

William R. Pulleyblank is the Director of Mathematical Sciences in IBM’s Research Division and the Director of the IBM Deep Computing Institute. He has also served as the Research Relation-
ship Executive responsible for the Finance sector, the Utility and Energy Services industry and for the Business Intelligence group at IBM. 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. He is a member of the Industrial Advisory Committee of the Institute for Mathematics and its Applications and has served on the board of governors and was chair of the board for a year. 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.

Peter Sarnak is a 1980 PhD graduate of Stanford University. He has been a tenured professor at the Courant Institute of Mathematical Sciences, Stanford University, and Princeton University, where he is a current faculty member and past department chair. He has held a Sloan Fellowship, NSF’s Presidential Young Investigator award, a Sherman Fairchild Visiting Professorship at Caltech, and won the Polya Prize of the Society for Industrial and Applied Mathematics. He has served on the scientific advisory committees of the Mathematical Sciences Research Institute (Berkeley), the Institut des Hautes Etudes Scientifiques (Paris), and the National Science Foundation. He serves on the editorial board of Annals of Mathematics and other leading research journals in mathematics, and has supervised twenty-three doctoral students.
OUR 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. PhiMac is a group of faculty, graduate students, and postdoctoral fellows based in the department and dedicated to the theory and practice of financial mathematics. They have cooperated effectively with the Fields Institute and have received support from MITACS. Over the next several years the department will establish the James Stewart Centre for Mathematics in Hamilton Hall, one of McMaster’s two historic buildings, with the goal of creating an integrated teaching, research and outreach centre to enhance the visibility, linkages and impact of mathematics at McMaster University and the larger community.

University of Toronto

The Department of Mathematics at the University of Toronto is the leading mathematics research department in Canada and compares well to the strongest departments in North America. Mathematics has been taught at the University of Toronto since 1827. The first Professor of Mathematics was appointed in 1843 and the first Ph.D. in mathematics was conferred in 1915. It went to Samuel Beatty, a student of John Charles Fields, whose will established the Fields Medal and whose name served as inspiration for the Fields Institute.

A central department in one of the largest universities on the continent, it comprises today a distinguished faculty of more than sixty mathematicians. Its research covers a broad spectrum, from mathematical foundations to interdisciplinary applications, from number theory and geometry to the analysis of shock waves and of financial risks. Research excellence is recognized nationally through the highest grant average and members of the department have delivered addresses at every International Congress of Mathematics in the recent past. The department is home to the winners of the first three CRM/Fields Prizes and to the only mathematician ever awarded the Canada Gold Medal for Science and Engineering.

The University of Toronto is not only committed to research excellence but as well to high quality education and training from the undergraduate to the postgraduate level.

Nowadays, faculty in the department teach close to 10,000 students each year, giving courses which cut across many disciplines. The mathematics undergraduate program is considered to be one of the best in North America. It prepares the brightest young minds to continue their education by doing graduate work at the best colleges and universities in North America and Europe. It trains many future mathematics and science teachers as well as mathematicians working in applications from engineering to the financial markets. 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 offered in most of the fields of pure and applied mathematics.

The department is involved with the Fields Institute at all levels, be it through organization and participation in its full-year scientific programs, events reaching out to high school teachers, or collaborative research projects within MITACS.
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 3,400 undergraduate, 250 graduate students, and 145 full-time professors, Waterloo ranks as the largest centre for mathematical, statistical 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 placed among the top 10 schools in each of the past eight years in the Association for Computing Machinery (ACM) International Programming Competition, and has been the world champion twice during that time. As well, Waterloo has placed in the top five in the Putnam Competition eight times in the past decade, and placed first in the most recent competition. Two of its team members where among the top six contestants (Putnam Fellows), and the highest ranked woman was a UW mathematics student. UW routinely ranks among the top three or four schools in terms of the number of students who place in the top 200 in the competition.

For seven 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.

University of Western Ontario

Activity in Mathematics and its applications at the University of Western Ontario is focused within the four Mathematical Science departments. There is growing collaboration between the departments, and links with all other sectors of the University. There is substantial interaction with and support from the private sector.

The Department of Applied Mathematics is one of only two in the country. The Department is research intensive: areas of study include mathematical biology, medical science, financial mathematics, materials modelling and nanotechnology, atomic and high-energy physics, fluid dynamics, engineering science, environmetrics, cryptography and high performance computing using Beowulf clusters. The Department participates in the Ontario Research Center for Computer Algebra, and in the Imperial Oil Centre for Mathematics Education. Members of the Department are at the forefront of a recently awarded multi-faculty, multi-university CFI grant for high performance computation.

The Department of Computer Science offers degrees at all levels in Computer Science, as well as degrees with specialization in Software Engineering. Research activities are grouped under the themes of Artificial Intelligence and Logic Programming, Graphics and Imaging, Software and Systems, Symbolic Mathematical Computation, and Theory of Computing, and include projects in cognitive science and machine vision, image compression, management of distributed systems, symbolic-numeric algorithms for polynomials, architectures for mathematical communication (MathML and OpenMath), programming languages, databases, molecular computing and bioinformatics, and automata theory and formal languages. The Department hosts the Ontario Research Centre for Computer Algebra. Major research projects are funded by international, federal, provincial and private sector sources.
Research and teaching in the Department of Mathematics is traditionally concentrated in the area of “pure” Mathematics. The Department offers programs at all undergraduate and graduate levels of instruction. Its research team is well known: faculty members have active research programs in homotopy theory, algebraic groups, algebraic K-theory, number theory, combinatorial algebra, non-commutative geometry, harmonic analysis, complex analysis and complex analytic geometry.

The Department of Statistical and Actuarial Sciences is active generally in data analysis and stochastic modelling. Data analytic methods include use of visualization in statistical analysis and the planning, design and analysis of data from a variety of types and sources, including the analysis of massive datasets as in fMRI and ultrasound imaging. Stochastic modelling includes queuing theory, risk theory, mathematical finance, actuarial models for nontraditional insurance products, utilization of health care resources, environmental impact assessment, reliability and quality control. The Department runs a statistical laboratory (STATLAB) that carries out contract consulting research.

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 processes, 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 a major recipient of NSERC research grants in mathematics and statistics. 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, the Department of Mathematics at York University ranked second among Canadian mathematics departments in citations per paper.

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. The Department also offers a Graduate Diploma in Financial Engineering, in collaboration with the Schulich School of Business. This diploma program provides the 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 or Portugal. In addition, a number of York faculty and graduate students are involved in the National Centre of Excellence project entitled “The Mathematics of Information Technology and Complex Systems” (MITACS).
PUBLICATIONS

Fields Institute Monographs

Volume


Fields Institute Communications

Volume


Financially as well as academically, the 1999-2000 fiscal year was a success. The increased level of activity at the Institute resulted in an increase in expenditures that was more than offset by the increase in revenues. As a result, the year ended with a net surplus from operations that was large enough to offset the remaining accumulated deficit, and to build a small positive balance.

The revenue that flowed to the Institute in the previous year from the curriculum revision project was more than replaced by the increase in funding from NSERC, from revenues generated by the Institute’s role as a MITACS administrator, and from new funding resulting from the Institute’s delivery of programs that reach out to a broader community. The reduction in revenues from university partners does not represent a decrease in university support, but rather the consequence of the Institute’s ability to collect the past due membership fees that had been written off.

The increase in expenses is attributable to the increased level of activity in support of programs and of MITACS. Elimination of the accumulated deficit has led to a situation where interest charges are now replaced by interest income.

With an operating surplus for two years in a row and the current elimination of the accumulated deficit, the Institute is in a solid financial position. These conditions enable it to move forward with confidence as it expands the range of research it stimulates and the breadth of applications it can sponsor.
AUDITORS’ REPORT

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, 2000 and the statement of operations and surplus (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 auditing standards generally accepted in Canada. 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, 2000 and the results of its operations for the year then ended in accordance with accounting principles generally accepted in Canada.

Toronto, Canada,

Chartered Accountants
The Fields Institute for Research in Mathematical Sciences

BALANCE SHEET

As at March 31

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ASSETS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Due from University of Toronto [note 3]</td>
<td>325,182</td>
<td>112,451</td>
</tr>
<tr>
<td>Accounts receivable</td>
<td>43,847</td>
<td>178,884</td>
</tr>
<tr>
<td>GST rebates receivable</td>
<td>40,429</td>
<td>43,533</td>
</tr>
<tr>
<td></td>
<td>409,458</td>
<td>334,868</td>
</tr>
</tbody>
</table>

| **LIABILITIES AND SURPLUS (DEFICIT)** |        |        |
| Liabilities                     |        |        |
| Accounts payable and accrued liabilities | 86,836 | 169,318 |
| Deferred revenue                | 280,038 | 218,205 |
| **Total liabilities**           | 366,874 | 387,523 |
| **Surplus (deficit)**           | 42,584  | (52,655) |
| **BALANCE**                     | 409,458 | 334,868 |

See accompanying notes
The Fields Institute for Research in Mathematical Sciences

STATEMENT OF OPERATIONS AND SURPLUS (DEFICIT)

Year ended March 31

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INCOME</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario Ministry of Education and Training</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating grant</td>
<td>1,000,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Mathematics Curriculum Project grant</td>
<td>-</td>
<td>309,600</td>
</tr>
<tr>
<td>Natural Sciences and Engineering Research Council of Canada</td>
<td>969,802</td>
<td>792,701</td>
</tr>
<tr>
<td>MITACS</td>
<td>126,365</td>
<td>-</td>
</tr>
<tr>
<td>University partners</td>
<td>132,500</td>
<td>143,500</td>
</tr>
<tr>
<td>Publications</td>
<td>24,586</td>
<td>41,908</td>
</tr>
<tr>
<td>Other external grants</td>
<td>175,480</td>
<td>85,472</td>
</tr>
<tr>
<td>Registration fees</td>
<td>39,870</td>
<td>-</td>
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<tr>
<td>Interest income</td>
<td>15,922</td>
<td>-</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>2,560</td>
<td>16,048</td>
</tr>
<tr>
<td><strong>Total Income</strong></td>
<td>2,487,085</td>
<td>2,389,229</td>
</tr>
</tbody>
</table>

|                |          |          |
| **EXPENSES**   |          |          |
| Salaries and benefits [scientific and support staff] | 969,586  | 897,828  |
| Employee research and administrative travel | 13,938   | 32,921   |
| Visitors travel | 705,633  | 593,939  |
| Communications | 47,463    | 27,430   |
| Printed material and publishing | 5,906    | 40,139   |
| Equipment rental, maintenance and lease | 77,220   | 56,730   |
| General and office supplies | 30,906   | 37,124   |
| Rent and services [note 3] | 524,519  | 525,346  |
| Professional services | 16,675   | 5,537    |
| Interest charge [note 3] | -        | 3,133    |
| **Total Expenses** | 2,391,846 | 2,220,127 |

|                |          |          |
| **Net surplus for the year** | 95,239  | 169,102  |

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficit, beginning of year</td>
<td>(52,655)</td>
<td>(221,757)</td>
</tr>
<tr>
<td><strong>Surplus (deficit), end of year</strong></td>
<td>42,584</td>
<td>(52,655)</td>
</tr>
</tbody>
</table>

See accompanying notes
NOTES TO FINANCIAL STATEMENTS

March 31, 2000

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 postdoctoral 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 accounting principles generally accepted in Canada. 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 period 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

March 31, 2000

4. STATEMENT OF CASH FLOWS

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

5. COMPARATIVE FINANCIAL STATEMENTS

The comparative financial statements have been reclassified from statements previously presented to conform to the presentation of the 2000 financial statements.