The Fields Institute is a centre of mathematical activity in Canada—a place where mathematicians from educational and research institutions in Canada and abroad, from business, industry, and financial institutions, can come together to carry out research on problems of mutual interest. The Institute provides a supportive and stimulating environment in which these diverse groups can interact. Its goal is to ensure that Canada plays a significant role in mathematical discovery and mathematical application in our modern technological society.
The Fields Institute is named after the Canadian mathematician John Charles Fields (1863–1932). Fields was a pioneer and visionary who recognized the scientific, educational, and economic value of research in the mathematical sciences. He is best known for establishing the premier international prize in mathematics—the Fields Medal—which is considered to be the Nobel Prize of mathematics. The Fields Institute occupies a building designed and constructed for Fields Institute activities situated on the University of Toronto campus.

Our purpose is to enhance mathematical activity in Canada by bringing together mathematicians from Canada and abroad, and by promoting contact and collaboration between professional mathematicians and the many diverse users of mathematics. The Institute supports research in pure and applied mathematics, statistics, and theoretical computer science. It also supports collaboration between mathematicians and those working in other areas such as engineering, the physical and biological sciences, medicine, economics, finance, telecommunications, and information systems.

The Institute building is designed to support and enhance these varied activities. Office space is provided for up to seventy-eight visitors; a supportive staff enables program participants to devote their energies to research; and full access to the excellent mathematics collection at the University of Toronto is provided.

The primary activities at the Institute are its thematic programs, which are one or two semesters in length. They involve participants from Canada and around the world, and include graduate students, postdoctoral fellows, as well as more senior and well-established scientists. The topics of thematic programs embrace all the mathematical sciences, as well as areas in which mathematics is, or can be, applied. Regular workshops, conferences, and graduate courses are planned by the program organizers to support these goals, while all administrative and non-scientific details such as housing are carried out by the Institute staff.

In addition to its thematic programs, the Fields Institute supports programs of shorter duration such as workshops and conferences, short courses, summer schools, recurring seminar series, and special lectures. Such activities are sometimes held off-site.

The Commercial and Industrial Mathematics Program (CIM) acts as a bridge between the mathematics community and businesses that benefit from research in the mathematical sciences. In this way, the CIM program seeks to communicate results in mathematics to the business community, and conversely to create an awareness among mathematicians of the needs of that community.

The Institute is strongly committed to mathematics education. The focus of these efforts is the Mathematics Education Forum, which holds monthly meetings at the Institute to discuss issues of mathematics education at all levels. The Forum brings together participants from high schools, school boards, faculties of education, mathematics departments in universities and colleges, and the private sector. One of the major contributions of the Forum to education was the 1998 revision of the Ontario high school mathematics curriculum, carried out through a contract of the Fields Institute with the provincial Department of Education.

Major funding is provided by the Ontario Ministry of Training, Colleges, and Universities and the federal Natural Sciences and Engineering Research Council (NSERC). Our six principal sponsoring universities are: McMaster University, the University of Ottawa, the University of Toronto, the University of Waterloo, the University of Western Ontario, and York University.

In addition there are nine affiliate universities: Iowa State University, the Ottawa-Carleton Institute for Mathematics and Statistics, Queen’s University, the University of Guelph, the University of Manitoba, the University of Maryland, the University of Notre Dame, the University of Saskatchewan, and the Atlantic Association for Research in Mathematical Sciences (AARMS). The corporate sponsors of the Fields Institute are Algorithmics, General Motors of Canada, Generation 5, Ibbotson Associates, the Individual Finance and Insurance Decisions (IFID) Centre, Siena Analytics LLC, and Sigma Analysis and Management.
FIELDS, RECOGNIZED FOR BOTH THE QUALITY of its programs and the broad interdisciplinary reach of its activity, has secured its place in the ranks of the world’s leading research institutes. If one needed proof, one had only to visit the College Street facility this summer and witness the topics discussed and the individuals involved. The summer school on Harmonic Analysis, the Trace Formula and Shimura Varieties, sponsored by the Clay Mathematics Institute in June, brought young researchers, graduate students, and postdoctoral students from around the world to work with leading mathematicians. The summer ended with a workshop on Statistical Genomics that drew together micro-biologists, geneticists, oncologists, bio-statisticians, and computer scientists.

The Institute continues to apply its resources and energy to mathematics in a variety of imaginative and innovative ways. Fields has been an active sponsor of mathematics education at all levels. The Junior Undiscovered Math Prodigies (JUMP) program, begun by John Mighton, is one such success story. JUMP is a volunteer-based tutoring organization for underprivileged elementary school children. Two hundred and fifty volunteers are now working with fifteen hundred elementary students in the greater Toronto area, and the program is attracting attention across the country.

Fields is in the midst of a change in leadership. The director, Ken Davidson, will complete his term next summer, while Bradd Hart relinquished his role as Deputy Director this summer. The current strength of the Institute is very much due to the vital scientific leadership that they, aided by the Scientific Advisory Panel, have provided to recent thematic and scientific programs and to those scheduled for future years. The reputation they have helped create for the Fields Institute has made the task of attracting their successors much easier than has been the case in the past. Their leadership has also built the Institute’s strong and effective support staff, which enables the myriad of events to take place in a fruitful research environment. It is with pleasure and anticipation that Ken and I look forward to working with Tom Salisbury, who was appointed Deputy Director this summer.

This message is always an appropriate place to express thanks. This year I would like to pay special tribute to Bradd Hart for his tireless efforts as Deputy Director, for the advances made by the Institute with respect to commercial and industrial mathematics programs, and for bridging the gap as Acting Director during the year between Don Dawson and Ken Davidson. All of us wish him well as he returns to McMaster University. I also want to thank the retiring members of the Board of Directors, especially Dr. Claudine Simson, who served as Vice-Chair for a number of years.

I speak on behalf of all the members of the Board of Directors when I state that Fields is well equipped to face the opportunities that lie ahead.

John R. Gardner, Chair
THE FIELDS INSTITUTE HAS COMPLETED another successful year. Looking through this report, you will see a broad spectrum of activities. The Institute continues to promote mathematics and the other mathematical sciences within the discipline, and to encourage collaboration with other areas in which we see an ever-increasing number of deep applications of mathematical ideas and methods.

We were supported by major grants from the Province of Ontario through the Ministry of Training, Colleges, and Universities, the Government of Canada through NSERC, six sponsoring universities (McMaster, Ottawa, Toronto, Waterloo, Western, and York) plus nine affiliate universities and seven corporate sponsors. I would like to thank all of them for their continuing essential support.

The biggest projects we take on each year are the thematic programs. This past year, we had two very successful half-year programs. The fall semester program on Set Theory and Analysis had more graduate students actually housed at Fields than any previous program. As a result, there was a constant sense of vibrancy and activity. It was necessary to get to afternoon tea promptly at 3:00 p.m. if you wanted any treats! The scientific quality of the program was high, and the interaction between analysts and set theorists at the workshops on dynamical systems and on Banach spaces was well appreciated by the participants.

In the winter, we had a second theme semester which focused on Automorphic Forms, Shimura Varieties, and L-functions. This was a very lively group as well. The challenge of keeping the three graduate courses up-to-date online as the term progressed kept instructors Jim Cogdell, Henry Kim, and Ram Murty busy. Their work will be published as a Fields monograph. In addition to two good workshops, there were several keynote lectures by Peter Sarnak and by Stephen Kudla.

This year was our first major attempt to run summer schools. We had three, all very successful. The gold standard in summer schools is represented by those funded by the Clay Mathematics Institute. We ran a Clay Summer School for the full month of June on Harmonic Analysis, the Trace Formula, and Shimura Varieties. It was led by James Arthur and Robert Kottwitz, with many other prominent leaders of the field also lecturing to over ninety graduate and postdoctoral students from around the world. In addition we ran two more modest summer schools for about forty students each. One, in Ottawa on Logic and Foundations of Computing, preceded a major international meeting on the same theme. The other, in Waterloo in July, on Mathematical Modelling in Medicine, will be reported in next year’s Annual Report. I hope to see more such activity every year.

We continue to support many events both at Fields and offsite, often but not exclusively on the campuses of our six sponsoring universities. There were many such events this year. At the Institute itself, we continue to host more than a half-dozen regular seminar series. In addition, there is a healthy complement of distinguished lectures, conferences, and other special events.

In 2003, we began collaborating with the Royal Canadian Institute, which has organized public lectures in science for a century in Toronto, to include mathematics talks in

Message from the Director

Kenneth R. Davidson
their series. The first took place this past winter when Stuart Whittington talked about random knotting, which occurs in particular in large molecules. There will be two public lectures this year, so watch for them.

We continue to be a meeting place for the Fields Mathematics Education Forum, which brings together practitioners of math education from the schools, colleges, and universities. A number of projects that they organized are reported herein. Also, I would like to mention JUMP, a tutoring operation for underprivileged children begun a few years ago by John Mighton. It has received some well-deserved press in the past year coincident with the release of John’s book, The Myth of Ability.

The commercial/industrial mathematics program continues to develop a number of activities with the participation of our various corporate sponsors. The monthly seminar on Quantitative Finance was particularly successful this year, and on at least two occasions, the audiences overflowed the Institute. This seminar is supported by MITACS, and we continue to work at developing successful MITACS activities.

Bradd Hart has just completed a four-year term as deputy director, which included one year as acting director when the director’s position was vacant. He has done great work for Fields, and has helped put the Institute in the strong position it is in today. My best wishes to him back at McMaster—though we still continue to draw on his help in various matters.

I extend a warm welcome to Thomas Salisbury, who took over as deputy director in August. Tom comes straight from a term as chair of Mathematics and Statistics at York University, and has extensive experience with Fields, the CMS, and the mathematical community. At the time of writing this report, he has already settled in and has proven that he will carry on the tradition of making Fields a great place to work.

Overall this has been an excellent year. I would like to take this opportunity to thank everyone who has been involved: the scientific organizers without whom we would have no activities; the participants from around the world; our board and advisory panels; our sponsors; and our staff, who set the standard for event support in mathematical institutes.

Kenneth R. Davidson, Director
As the notion of infinity is deeply rooted in the human mind, our common sense rebels when modern theories of physics try to convince us that space is discrete, and, Zeno’s paradox notwithstanding, we see it as a continuum. This raises a fundamental question. Which aspects of the mathematical analysis of space can be discretized and which rely on the use of the infinite in an essential way? This question, in various guises, was the focus of the Fields Institute’s semester on Set Theory and Analysis.

The semester began August 19 with two weeks of lectures for graduate students designed to provide them with preparatory background for the two graduate courses that followed.

One of these two courses, on Descriptive Set Theory, was organized by a leading expert in the field, Howard Becker (South Carolina). This subject can be thought of as a response to the pathologies arising from the Axiom of Choice. Descriptive set theorists focus their attention on those sets arising naturally in mathematics, sets which might be said to have a “description.” One of the motivations for such a study is that, while the Axiom of Choice provides examples of sets without a description, there are reasonable alternatives to this axiom that do not lead to such sets. Furthermore, it is consistent that all the classical questions of analysis about such sets—questions concerning measurability, the Baire Property and other, similar analytic properties—can be answered. In other words, there is a satisfactory theory of analysis without the Axiom of Choice. This can be viewed as a prototype for an ambitious project intended to resolve the Continuum Hypothesis which formed the basis of the Coxeter Lectures by W. Hugh Woodin (Berkeley).

Becker took the course in a different direction, however. The first four weeks were devoted to discussing the main results forming the foundations of what would be emphasized during the October workshop on Dynamics and Borel Relations.

The second graduate course, taught jointly by Ilijas Farah (York) and Stevo Todorcevic, concentrated on the use of infinite dimensional pigeonhole principles and Ramsey theoretic techniques in Banach spaces. Topics covered in their course, along with others, were the focus of a November workshop on the Geometry of Banach Spaces and Infinite Dimensional Ramsey Theory.

The program’s seminar series continued on into the winter and spring of 2003.

The Thematic Program on Set Theory and Analysis included the following activities:

**GRADUATE COURSES**

**Summer Course of Twelve Preparatory Lectures and Exercise Sessions on Set Theory and Analysis**
August 19–29, 2002
Instructors: Ilijas Farah, Paul Larson (Toronto), Juris Steprans, Paul Szeptycki (York), and Stevo Todorcevic

**Partition Theory and Banach Spaces**
September 9–December 16, 2002
Instructors: Ilijas Farah and Stevo Todorcevic

**Descriptive Set Theory**
September 10–December 17, 2002
Organizer: Howard Becker
Instructors: Howard Becker, Ari Brodsky (Toronto), Timothy Cookson (Wisconsin), Alain Louveau (Paris VI), Henryk Michalewski (Warsaw)
WORKSHOPS

Workshop on Descriptive Set Theory, Analysis, and Dynamical Systems
October 6–12, 2002
Organizers: Ilijas Farah, Greg Hjorth (UCLA), Alexander Kechris

Workshop on Geometry of Banach Spaces and Infinite Dimensional Ramsey Theory
November 11–15, 2002
Organizers: Edward Odell (Texas–Austin), Thomas Schlumprecht (Texas A&M), Stevo Todorcevic, Nicole Tomczak-Jaegermann (Alberta)

LECTURES

Coxeter Lectures
November 4–6, 2002
W. Hugh Woodin
The Continuum Hypothesis and the $\Omega$ Conjecture
Strong Axioms: Determinacy and Large Cardinals
Extender Sequences and Beyond

Special Lectures
October 1–3, 2002
Saharon Shelah (Hebrew University and Rutgers)
Three lectures on Adding Measures to Normed Forcing

SEMINARS

September–December, 2002

Spiros Argyros (Athens)
A Banach Space with Small Operator Algebra, parts 1 and 2

Tomek Bartoszynski (Boise State)
Additivity Properties and Topological Diagonalization

Jörg Brendle (Kobe)
Shattered Iterations

Lev Bukovsky (University of P.J. Safarik)
On Hurewicz’s Properties

Maxim R. Burke (PEI)
Products of Linearly Ordered Spaces

Gabriel Debs (Paris VI)
Some Undecidable Properties of Borel Sets

Ilijas Farah (York)
Borel Subgroups of a Polish Group

Valentin Ferenczi
On the Number of Non-isomorphic Subspaces of a Banach Space

David H. Fremlin (Essex)
Weakly Alpha-favourable Measure Spaces

Stefan Geschke (Berlin)
Ideals Generated by Graphs of Functions and Continuous Ramsey Theory

Gary Gruenhage (Auburn)
Games, Eberlein Compacts, and Baire Spaces

Alexander Kechris
Rigidity, Cocycles, and Equivalence Relations

Menachem Kojman (Ben Gurion University of the Negev)
Set Theoretic Problems Resulting from Convexity

Piotr Koszmider (São Paulo)
A Banach Space $C(K)$ with Few Operators

Wieslaw Kubis (Katowice)
Closed Uncountably Convex Sets in Euclidean Spaces

Paul Larson
Stationary Tower Forcing

Alberto Marcone (Udine)
Some Classification Results in Continuum Theory

Benjamin Miller (Caltech)
Order-preserving Borel Embeddings between Borel Automorphisms

Peter Nyikos (South Carolina)
Updates on a 1903 Paper by G.H. Hardy Hereditarily Normal Manifolds

Janusz Pawlikowski (Wrocław)
An Axiomatic Approach to Sacks Forcing

René Schipperhuis (Vienna)
Boris Model Games on Cardinals

Slawomir Solecki (Illinois)
Algebraic Properties of Countable Groups and Haar Null Sets

Stevo Todorcevic
1. Universally Meager Sets and the Generic Differentiability and Fragmentability in Banach Spaces
2. Coding with the Rho-function

Jan van Mill (Vrije Universiteit)
Homogeneous Compacta
Boban Velickovic (Paris VII)
*Back-and-Forth Properties of Uncountable Cardinals*

Teruyuki Yorioka (Kobe)
*The Consistency of Martin’s Axiom + There Are (c,c)-gaps But No (ω₁,c)-gaps*

**SEMINARS**
April–June, 2003
Daniel Deaconu (York)
*On Locally Compact Abelian Topological Groups and kk-groups (Part 1)*
*On Locally Compact Abelian Topological Groups and kk-groups (Part 2)*

Debora DiCaprio (York)
*Orderability and Continuous Selection for Wijsman and Vietoris Hyperspaces*

Ilijas Farah (York)
*Characterizing Measure Algebra*
*Pathological (and Somewhat Exhaustive) Submeasures*

Paul Larson (Sao Paulo)
*Q-sets and Saturatedness of Ideals on omega₁*

Frank Tall (Toronto)
*The Metrizability of Hereditarily Normal Manifolds: Reflections on Countable Chain Condition Compacta*

**Short Course on Partition Theory and Banach Spaces**
September 9–December 16, 2002
Instructors: Ilijas Farah (York) and Stevo Todorcevic (CNRS–Paris and Toronto)

The purpose of the course was to give a short overview of the basic techniques of Ramsey theory that have been shown to be relevant in Banach space theory. The instructors concentrated on the use of infinite dimensional pigeonhole principles and Ramsey theoretic techniques in Banach spaces. If one is to embed a classical Banach space—that is, a Banach space with a nicely behaved basis—into an arbitrary Banach space, then one must find candidates for a basis which at least behave pairwise in the same way. This suggests a relationship with Ramsey-type theorems. The best-known of these says that if the unordered pairs of a countably infinite set are coloured with two colours, then there is an infinite set all of whose pairs have the same colour. For applications to Banach spaces, where the behaviour of all finite subsets of a basis—not just pairs—is important, this result is much too weak.

Farah and Todorcevic examined sophisticated refinements of Ramsey-type theorems in their course and looked at applications to Banach spaces. Perhaps the most striking example of this is to be found in Gowers’s Partition Theorem, a crucial step in proving the dichotomy theorem which is part of his work on the unconditional basis problem cited in his Fields Medal award: every Banach space contains a subspace which either has an unconditional basis or is hereditarily indecomposable. These topics, along with others, were the focus of the November workshop.

**Short Course on Descriptive Set Theory**
September 10–December 17, 2002
Organizer: Howard Becker (South Carolina)

Instructors: Howard Becker, Ari Brodsky (Toronto), Timothy Cookson (Wisconsin), Alain Louveau (Paris VI), Henryk Michalewski (Warsaw)

Descriptive Set Theory can be thought of as a response to the pathologies arising from the Axiom of Choice. Descriptive set theorists focus on those sets arising naturally in mathematics which can be said to have a “description” and to showing that there is a satisfactory theory of analysis without the Axiom of Choice.

Becker devoted the first four weeks to discussing the main results forming the foundations for the October workshop on Descriptive Set Theory, Analysis, and Dynamical Systems. He provided a context by means of the classical results on the measurability of sets of reals. Is there a way to make choices from orbit equivalence classes in a coherent way that avoids the non-measurability phenomenon? More generally, what happens when orbit equivalence is replaced by arbitrary, yet describable, equivalence relations? For example, the Jordan canonical form provides a coherent way of choosing representatives of complex nxn matrices under the equivalence relation of similarity. Analogous, well-known theorems yield classification results for operators using spectra, ergodic mappings using recurrent points, vector spaces using dimension, compact manifolds using algebraic invariants as well as many other examples. In other areas of mathematics, however, all attempts at finding characterization theorems have failed, and one must face the possibility that no such results exist. How does one prove such a non-existence result?
One answer is provided by a strong dichotomy theorem—the Harrington-Kechris-Louveau theorem—which is about the impossibility of finding representation theorems. For example, the problem of classifying abelian groups of rank n+1 has been shown by Hjorth, by Adams, and by Kechris, to be a strictly harder problem (with respect to a partial ordering on Borel equivalence relations) than that of classifying abelian groups of rank n. Thus while there has been a satisfactory classification (due to Baer in the 1930s) of abelian groups of rank 1, one for abelian groups of arbitrary finite rank has not been found.

Workshop on Descriptive Set Theory, Analysis, and Dynamical Systems
October 6–12, 2002
Organizers: Ilijas Farah (Staten Island College), Greg Hjorth (UCLA), Alexander Kechris (Caltech)

Descriptive set theory is the study of definable sets and functions in Polish (complete separable metric) spaces. In recent decades, intriguing connections have been discovered between descriptive set theory and other fields of mathematics—classical real analysis, probability theory, potential theory, harmonic analysis, Banach space theory, and ergodic theory.

More recently, a new area has emerged that considers the development of a theory of complexity of classification problems in mathematics and the closely related theory of descriptive dynamics, i.e., the theory of definable actions of Polish groups on Polish spaces.

This work brings descriptive set theory into contact with current developments in other areas of mathematics such as dynamical systems, including ergodic theory and topological dynamics, the theory of topological groups and their representations, operator algebras, and geometric and combinatorial group theory. Moreover, it provides new insights into the traditional relationships of descriptive set theory with other areas of mathematical logic, for example, with recursion theory concerning the global structure of Turing degrees and with model theory through the Topological Vaught Conjecture and the general study of the isomorphism relation on countable structures. This subject is developing rapidly, but many fundamental questions remain.

The workshop brought together mathematicians interested in descriptive set theory and its applications and connections in order to survey recent developments and to encourage collaboration. The format left ample time for informal discussions among the more than seventy participants, of whom approximately twenty were graduate students and postdoctoral fellows.

Talks ranged over many topics—orbit equivalence theory, superrigidity and its applications to classification problems in algebra, descriptive aspects of ergodic theory and topological dynamics, topological groups, the theory of reducibility for equivalence relations and orders, and geometric and descriptive properties of planar sets. Overall, the picture that emerged was of a vibrant field at the interface of descriptive set theory with analysis and dynamical systems.

Finally, there was a special session on Future Directions in Descriptive Set Theory, Analysis, and Dynamics, which gave young researchers and students the opportunity to hear senior scholars discuss the most fruitful avenues for future research. Each talk included an introductory overview and many open problems. The three speakers were A. Kechris, D. Mauldin (N. Texas), and J. Steel (Berkeley).
The workshop was supported by the Fields Institute and the U.S. National Science Foundation.

Speakers:
Scot Adams (Minnesota)
The Origins of Lattice Superrigidity and Dynamical Superrigidity
Howard Becker (South Carolina)
Polish Group Actions and Generalized Model Theory
Matt Foreman (UC Irvine)
The Classification of Measure Preserving Systems
Greg Hjorth (UCLA)
Treeable Equivalence Relations and Dye’s Theorem
Vladimir Kanovei (Moscow Centre for Continuous Mathematical Education)
Reducibility of Equivalence Relations in “Hyperfinite” Descriptive Set Theory
Robert Kaufman (UI Urbana-Champaign)
Mixing and Descriptive Set Theory
Steve Jackson (N. Texas)
On the Existence and Properties of Steinhaus Sets
Dominique Lecomte (Paris VI)
About the Complexity of Borel Subsets of the Plane
Alain Louveau (Paris VI)
Complete Analytic Equivalence Relations and Orders
M. Nadkarni (Mumbai)
Descriptive Discussion of Well-Known Problems
Italy Neeman (UCLA)
Effective Cardinalities along the Wadge Hierarchy
Vladimir Pestov (Ottawa)
The Fixed-Point-on-Compacta Property of Topological Groups
Slawomia Solecki (UI Urbana-Champaign)
Measuring Subsets of Discrete Groups and Haar Null Sets
Simon Thomas (Rutgers)
Superrigidity and Classification Problems for Torsion-free Abelian Groups of Finite Rank
Benjamin Weiss (Hebrew University)
Generic Dynamics

Workshop on Geometry of Banach Spaces and Infinite Dimensional Ramsey Theory
November 11–15, 2002
Organizers: Edward Odell (Texas–Austin), Thomas Schlumprecht (Texas A&M), Stevo Todorcevic (CNRS–Paris and Toronto), and Nicole Tomczak-Jaegermann (Alberta)

One of the major successes of set theory in analysis has been the use of Ramsey theory in the study of Banach spaces. This began thirty years ago with the introduction of spreading models by Brunel and Sucheston. The involvement of infinite dimensional Ramsey theory was raised recently to a higher level of sophistication by W.T. Gowers, who constructed a new block Ramsey theorem.

The strongest potential Ramsey theorem in a Banach space setting can be stated as follows. Is every uniformly continuous real valued function on a unit sphere of a Banach space oscillation stable? Called the “distortion problem,” this was solved in the 1990s by Odell and Schlumprecht in the negative. The existence of a distortable space of “bounded distortion,” however, remains open. Such a space could lead to some sort of weak Ramsey theorem. Interesting work on this problem has been done by Odell, Schlumprecht, Maurey, Milman, and Tomczak-Jaegermann, among others.

Recent solutions of the two most famous problems in this area—the distortion problem and the unconditional basic sequence problem (Gowers and Maurey)—are closely tied to a deeper understanding of a particular example of a non-classical Banach space due to Tsirelson. The inductive definition of its norm involving “admissible families” of sets makes the space susceptible to a set-theoretical analysis where the notion of “admissible” appears with a different name, “relatively small” (Ketonen-Solovay). Gowers’s Ramsey-theoretic dichotomy for Banach spaces may also be susceptible to further set-theoretical analysis, especially in the direction of Ellentuck-type theorems, which are abundant in the infinite dimensional Ramsey theory.

The highlight of the conference was the presentation of a beautiful new construction by Spiros Argyros (Athens), Jordi Lopez-Abad (Paris VII), and Stevo Todorcevic extending to a non-separable setting a previously known separable construction of spaces without unconditional basic sequences. Seemingly impossible, this was accomplished using deep results from set theory. This astounding marriage of set theory and Banach space theory may herald further beautiful things to come.
Talks at the conference covered a wide variety of interdisciplinary connections. Some were expository; others explained recently discovered results. In addition, a panel on future directions presented and discussed a number of open interdisciplinary problems.

**Speakers:**
Dale Alspach (Oklahoma State)  
*Some Ordinal Indices in Banach Space Theory*

George Androulakis (South Carolina)  
*A Property of Strictly Singular 1-1 Operators*

Spiros Argyros (Athens)  
*Banach Spaces with Small Operator Algebras*

Alexander D. Arvanitakis (Athens)  
*The Generalized Banach Contraction Theorem*

Valentin Ferenczi (Paris VI)  
*On a Question by Haskell P. Rosenthal*

Gilles Godefroy (Pierre et Marie Curie)  
*Rosenthal Compact Sets and Analytic Filters*

Petr Hajek (Czech Academy of Science)  
*Quantitative Krein Theorem*

Haskell Rosenthal (Austin)  
*Recent Progress and Open Problems in the Theory of Non-commutative Infinite-dimensional Banach Spaces*

Jose Iovino (San Antonio)  
*Definability of Types over Banach Spaces*

Vassilis Kanellopoulos (National Technical University of Athens)  
*Ramsey Families of Subtrees of the Dyadic Tree*

Robert Kaufman (UI–Urbana-Champaign)  
*Complexity of a Certain Set of Norms in a Banach Space*

Dominique Lecomte (Pierre et Marie Curie)  
*How Can We Recover Baire Class One Functions?*

Denny H. Leung (National University of Singapore)  
*U*-spreading Models in Mixed Tsirelson Spaces*

Jordi Lopez-Abad (Paris VII)  
*Coding into Ramsey Sets*

Edward Odell (Texas–Austin)  
*Ramsey Methods in Banach Spaces*

Anna Pelczar (Jagiellonian University)  
*Combinatorial Techniques in the Classification of Banach Spaces*

Bunyamin Sari (Alberta)  
*On Spreading Models of Orlicz Sequence Spaces*

Thomas Schlumprecht (Texas A&M)  
*Asymptotic Structure and Games of Higher Complexity in a Banach Space*

Nicole Tomczak-Jaegermann (Alberta)  
*Distorting Tsirelson Space*
The Coxeter lecturer for the thematic program on Set Theory and Analysis, W. Hugh Woodin, gave three lectures that cover some of the major recent advances of modern set theory. The first, entitled The Continuum Hypothesis and the \( \Omega \) Conjecture, was perhaps the one most accessible to a general mathematical audience. The efforts of Gödel and Cohen to solve Cantor's Continuum Hypothesis (CH) have been the driving forces behind many developments of modern set theory. Yet, one still hears the question “Does CH have an answer at all?” Woodin presented an attractive new way of looking at this sort of problem. To solve a problem such as CH, for which one can build forcing extensions of the set-theoretic universe that would give different answers to the problem, one needs to define notions of mathematical truth (logics), which are immune to the effects of forcing. The logics should be definable and generically invariant (i.e., invariant under forcing extensions). The strongest such logic is the \( \Omega^* \) logic defined by letting a sentence be provable if it is valid in forcing extensions of all rank-initial segments of the universe that satisfy ZFC. While this logic does satisfy generic invariance, its definability is currently only a conjecture (“The \( \Omega \) Conjecture”) that touches some of the most important parts of modern set theory.

In the second lecture, Strong Axioms: Determinacy and Large Cardinals, one of the most basic question about \( H(\omega_2) \) is reformulated, modulo the \( \Omega \) Conjecture, as “how complicated are the \( \Omega \)-recursive sets of integers?” It turns out that the answer to this question involves deep elements of both descriptive set theory and the fine structure theory, two of the most prominent themes of modern set theory.

In the final lecture, Extender Sequences and Beyond, Woodin presented his view of the problem of finding inner models for large cardinals far beyond the present state of the art in this area of set theory. After isolating the main obstacles that one faces in this theory—such as, for example, “the moving space problem”—the third lecture gave us a rather clear indication how the \( \Omega \) Conjecture appears rather naturally in this area of set theory in the form of an “iteration hypothesis.”

As a part of the thematic program on Set Theory, Saharon Shelah delivered three lectures in October. Normed forcing first established its usefulness in Shelah’s seminal proof that the splitting number can be greater than the unboundedness number. The essential idea was to use measures (often on finite sets) to control the splitting nodes of trees used as forcing conditions. These ideas later evolved into a sophisticated theory of “creature forcing,” which is described in a short book by A. Roslanowski and S. Shelah. Recently, in further joint work with A. Roslanowski, a simple form of integration was added to the mix, thus allowing the solution of several longstanding problems in the theory of measurable functions.

For example, it has been shown to be consistent with set theory that all real valued functions are continuous on a non-measurable set of reals. The same techniques have also been applied to questions dealing with superposition measurable functions—namely, those functions from the plane to the reals whose restriction to the graph of any measurable function is measurable. The study of a certain class of solutions to the Cauchy problem leads to the question of whether every superposition measurable function is actually measurable. Measured creatures can be used to show that the answer is consistently positive.

The first lecture provided an introduction and overview of the main results, while the last two lectures gave details for experts in the field.
Automorphic Forms January–June 2003

(including Clay Mathematics Institute Summer School on Harmonic Analysis, Trace Formulas, and Shimura Varieties)

Scientific Organizers: James Arthur (Toronto), Thomas Haines (Maryland), Henry Kim (Toronto), Ram Murty (Queen’s), George Pappas (Michigan State), Robert Kottwitz (Chicago), and Freydoon Shahidi (Purdue)

The theory of automorphic forms is a wide and deep subject touching many areas of mathematics. The program concentrated on the geometric and analytic aspects of the subject, which have far-reaching applications in classical number theory.

The Riemann zeta function is an archetypal example of a vast family of L-functions attached to automorphic representations. These L-functions were first defined by Langlands, and their study forms the central focus of what is now called the Langlands program. Just as the Riemann zeta function is intimately connected to the study of the distribution of prime numbers, these L-functions have profound connections to classical problems of analytic and algebraic number theory as well as arithmetic geometry. In addition, the Langlands program has ramifications to other parts of mathematics. The thematic program, however, focused on some recent developments. In particular, it concentrated on the work of Kim and Shahidi on the analytic continuation of a family of L-functions called the symmetric power L-functions.

The program included three instructional courses given by Jim Cogdell (Oklahoma State and Fields), Ram Murty, and Henry Kim. There were two workshops, one organized by Thomas Haines and George Pappas, and the second by Ram Murty and Henry Kim. The program also included a Distinguished Lecture Series, consisting of three lectures by Peter Sarnak (Princeton) on Automorphic L-functions and Equidistribution. The spring 2003 Coxeter Lecture Series was given by Stephen S. Kudla (Maryland), who spoke on the Arithmetic Theta Series. The program concluded with a month-long summer school in June—the Clay Mathematics Institute Summer School on Harmonic Analysis, Trace Formulas, and Shimura Varieties, organized by James Arthur, David Ellwood (Boston and CMI); and Robert Kottwitz.

The thematic program on Automorphic Forms included the following activities:

**GRADUATE COURSES**

**Automorphic Functions**
January 21–May 1, 2003
Instructor: Henry Kim (Toronto)

**Symmetric Power L-functions and Applications to Analytic Number Theory**
January 21–May 1, 2003
Instructor: Ram Murty (Queen’s)

**L-functions, Converse Theorems, and Functoriality for GL(n)**
January 21–April 29, 2003
Instructor: Jim Cogdell (Oklahoma State and Fields)

**WORKSHOPS**

**Workshop on Shimura Varieties and Related Topics**
March 4–8, 2003
Organizers: Thomas Haines (Maryland) and George Pappas (Michigan State)

**Workshop on Automorphic L-functions**
May 5–9, 2003
Organizers: Henry Kim (Toronto) and Ram Murty (Queen’s)

**LECTURES**

**Coxeter Lectures**
March 10, 11, 12, 2003
Stephen S. Kudla (Maryland)

**Arithmetic Theta Series**

**Distinguished Lecture Series**
April 9, 10, 11, 2003
Peter Sarnak (Princeton)

**Automorphic L-functions and Equidistribution**

**SUMMER SCHOOL**

Clay Mathematics Institute Summer School on Harmonic Analysis, Trace Formulas, and Shimura Varieties
June 2–27, 2003
Organizers: James Arthur (Toronto), David Ellwood (Clay Mathematics Institute), Robert Kottwitz (Chicago)
The thematic program included three weekly courses held at the Fields Institute. It was somewhat unusual in that they were all concentrated on the same topic—recent cases of Langlands Functoriality. The Tuesday morning course, by Cogdell, dealt with the theory of L-functions for GL(n) in terms of their integral representations. It covered classical modular forms, automorphic forms, L-functions for GL(n), converse theorems, and finally, combining the converse theorem with the Langlands–Shahidi method of understanding L-functions, new cases of functoriality from classical groups to GL(n).

The Tuesday afternoon course given by Kim was concerned with developing the Langlands-Shahidi method of controlling the analytic properties of automorphic L-functions. Kim developed the theory of algebraic groups, Eisenstein series, the Langlands-Shahidi method, and then combined this method with the converse theorem for GL(n) to derive the new cases of functoriality, particularly the symmetric cube and fourth power functorialities. The third course, by R. Murty, took place on Thursday mornings. Less directed than the other courses, it was more of a selected-topics course that dealt with the many applications in analytic number theory of these new cases of functoriality, particularly the symmetric power functorialities. As a result, the three courses were highly co-ordinated and intertwined, and provided a particularly directed sense of identity for the thematic program.

The MEMBERS’ SEMINARS, held Thursday afternoons, gave members of the thematic program a chance to speak on their own work. The range of speakers and topics was broad—from Joseph Bernstein (Tel Aviv), a senior participant, to Kimball Martin (Cal Tech), a graduate student. Everyone who desired to speak was given the opportunity to do so (as well as some who possibly had to be convinced).

Workshop on Shimura Varieties and Related Topics
March 4–8, 2003
Organizers: Thomas Haines (Maryland) and George Pappas (Michigan State)

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

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

**Speakers:**
- James Arthur (Toronto)
  *On the Universal Groups in Automorphic Forms and Algebraic Geometry*
- Don Blasius (UCLA)
  *Weight-monodromy Conjecture for Some Simple Shimura Varieties*
- Ching-Li Chai (Pennsylvania)
  *The Hecke Orbit Problem: Hecke Symmetries and Oort Fibration*
- Laurent Fargues (Paris VII, Jussieu)
  *Boundary Cohomology of Lubin–Tate Spaces*
- Jens Funke (Fields)
  *(Singular) Theta Lifts and the Construction of Green Currents and Differential Characters for Cycles in Locally Symmetric Spaces of Orthogonal and Unitary Type*
- Ulrich Goetz (Köln)
  *The Jordan–Hoelder Series of Nearby Cycle Sheaves on Some Shimura Varieties and Affine Flag Varieties*
- Eyal Gorlin (McGill)
  *Local Models and Displays*
- Haruzo Hida (UCLA)
  *Automorphism Groups of Shimura Varieties mod $p$*
- Tetsushi Ito (Max-Planck Institut)
  *Weight-monodromy Conjecture for $p$-adically Uniformized Varieties*
- Gerard Laumon (Paris-Sud, Orsay)
  *On the Fundamental Lemma for Unitary Groups*
- Ron Livne (Hebrew University, Jerusalem)
  *Local Points and Parity of Jacobians*
- Elena Mantovan (Berkeley)
  *On Certain Unitary Group Shimura Varieties*
- Sascha Orlik (Leipzig)
  *The Cohomology of Period Domains*
- Michael Rapoport (Köln)
  *An Update on Affine Deligne–Lusztig Varieties*
- Jeremy Teitelbaum (Illinois, Chicago)
  *$p$-adic Analytic Representation Theory and Inklings of a $p$-adic Analytic Langlands Correspondence*
- Torsten Wedhorn (Köln)
  *A Generalization of the Ekedahl–Oort Stratification*
- Uwe Weselmann (Heidelberg)
  *A Generalization of the Ekedahl–Oort Stratification*
- Chai-Fu Yu (National Tsing-Hua University)
  *Fine Structures and Hecke Orbit Problems of Hilbert–Blumenthal Varieties*

**Workshop on Automorphic L-functions**

May 5–9, 2003

Organizers: Henry Kim (Toronto) and Ram Murty (Queen’s)

With more than forty participants and fifteen invited speakers, the workshop on Automorphic L-functions was stimulating and very enjoyable. A leisurely schedule of three lectures each day allowed for opportunities for informal discussions and the free exchange of ideas among participants. Some of the topics covered in the lectures included several aspects of functoriality, Selberg’s...
conjectures, summatory functions, convolution problems, Artin L-functions and applications, and distribution of modular symbols and elliptic curves.

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

**Speakers:**
- James Arthur (Toronto)
  *Weighted Orbital Integrals and Transfers*
- A. Booker (Princeton)
  *Converse Theorems and Artin’s Conjecture*
- William Casselman (UBC)
  *Functoriality for the Classical Groups*
- Alina Carmen Cojocaru (Fields)
  *Applications of the Chebotarev Density Theorem to Elliptic Curves*
- Chantal David (Concordia)
  *On the Vanishing of Twisted L-functions of Elliptic Curves*
- John Friedlander (Toronto)
  *Summation Formulae for Coefficients of L-functions*
- Harald Helfgott (Princeton)
  *On the Distribution of Rooted Numbers in Families of Elliptic Curves*
- Wentang Kuo (Queen’s)
  *Selberg’s Conjectures and L-functions*
- Jung-Jo Lee (Queen’s)
  *An Application of Mumford’s Gap Principle*
- Philippe Michel (Montpellier II)
  *On the Shifted Convolution Problem*
- Kumar Murty (Toronto)
  *Pair Correlation and Artin L-functions*
- Yiannis Petridis (CUNY)
  *Distribution of Modular Symbols*
- A. Raghuram (Purdue)
  *Conductors and Newforms for SL(2)*
- Song Wang (Yale)
  *On the Cospirdality of the Kim–Shahidi Transfer of GL(2)×GL(3) to GL(6)*

**COXETER LECTURE SERIES**

**Stephen S. Kudla**

*Arithmetic Theta Series*

March 9, 10, 11, 2003

The spring 2003 Coxeter lectures were given by Stephen S. Kudla (Maryland) on the *Arithmetic Theta Series*. Kudla’s main research interests lie within number theory, in particular in the area of automorphic forms and theta series. One constant theme of his work throughout his career has been his interest in the relationship of automorphic forms to differential and arithmetic algebraic geometry.

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

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

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

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

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

**Clay Mathematics Institute Summer School on Harmonic Analysis, the Trace Formula, and Shimura Varieties**

June 2–27, 2003
Organizers: James G. Arthur (Toronto), David Ellwood (Clay Mathematics Institute), Robert Kottwitz (Chicago)

The Langlands program is a series of interlocking conjectures that predict deep relations between objects arising in algebraic geometry, number theory, and representation theory. While there are a number of excellent articles providing an overview of the program, it has been very difficult for students and others to acquire the background in harmonic analysis, the trace formula, and Shimura varieties that they need to get started in the program. With the generous financial support of the Clay Mathematics Institute, the Fields Institute ran a Summer School June 2–27, 2003, designed to provide exactly this background for its participants. During the first three weeks, there were three longer series of lectures on the fundamental topics of the Summer School, and the final week was taken up with shorter series on more advanced topics. In addition, during the first week, Fiona Murnaghan (Toronto) provided the background on reductive groups required for the remaining lectures in a series of lectures entitled Background from Algebraic Groups.

The trace formula was introduced by Selberg in the context of semisimple groups, and extended by Arthur to reductive groups. It has become a basic tool for the understanding of automorphic forms on general reductive groups. In fifteen lectures on *Introduction to the Trace Formula*, James G. Arthur (Toronto) described the global trace formula for a reductive group over a number field, discussed its proof,
and introduced some of the local objects that occur in it. These local objects—more specifically, the orbital integrals and characters of reductive groups over local fields—were the topic of ten lectures on Harminic Analysis on Reductive Groups and Lie Algebras by Robert Kottwitz (Chicago). He also discussed a number of other topics, such as Shalika germs and Howe’s finiteness theorem. The latter was examined in more detail during the final week by Stephen DeBacker (Harvard) in lectures on An Introduction to Homogeneity with Applications. Applications of the trace formula lead to the verification of identities between integrals on reductive groups. A collection of such conjectural identities has become known as the “Fundamental Lemma,” a name that reflects the optimism of the founders of the subject rather than our current knowledge. It was the topic of the lectures of Tom Hales (Pittsburgh) also during the final week on An Introduction to the Fundamental Lemma.

Shimura varieties are the higher dimensional analogues of elliptic modular curves. Their role in the Langlands program is as a source of the Galois representations conjectured to correspond to automorphic representations and as a test of Langlands’s conjecture that all motivic L-functions are automorphic. In fifteen lectures entitled Introduction to Shimura Varieties, James S. Milne (Michigan) initially introduced Shimura varieties as complex manifolds, but then showed that they are naturally endowed with the structure of an algebraic variety over a number field. In his lectures during the final week on the Geometry and Topology of Compactifications of Modular Varieties, Mark Goresky (Institute for Advanced Study) explained the topology of the boundary of Shimura varieties. Milne also mentioned briefly in his lectures the problem of computing the local zeta function of a Shimura variety at a good prime. This topic was pursued in more depth, and also in the case of bad reduction, by Tom Haines (Maryland) during the final week. In his lectures on Bad Reduction of Shimura Varieties, he showed the way in which it led to orbital integrals, the trace formula, and the Fundamental Lemma, thereby tying together the two main strands of the Summer School.

The notes of most of the lectures, as well as recordings of the spoken lectures, are available on the Fields Institute website. Eventually, revised and expanded versions of the lectures will be published as a book in the CMI monograph series. It is hoped that this will be a valuable resource for many years to come for those wishing to learn the subject.

It was no surprise that the Summer School attracted a talented group of young mathematicians. What was surprising was the geographic diversity of their origins. Although most are graduate students or postdoctoral fellows at North American universities, and the remainder are at major Asian, European, or Israeli universities, their countries of origin include China, Indonesia, India, Iran, Korea, Macedonia, Peru, Romania, Pakistan, Turkey, and Vietnam among others. In addition, although the students shared a common interest in the main topics of the summer school, their mathematical backgrounds were almost equally diverse.

Instructors and lecturers commented on their pleasure in teaching such a lively and engaged audience of young mathematicians.
Scientific Organizers: Uri Ascher (UBC), Michel Fortin (Laval), Hermann Brunner (Memorial), Peter Forsyth (Waterloo), Tony Chan (UCLA), Alan George (Waterloo), Tom Coleman (Cornell), Wayne Enright (Toronto), Joe Flaherty (Rensselaer), Kenneth Jackson (Toronto), William Langford (Guelph), Bob Russell (SFU), and Sam Shen (Alberta)

Numerical Analysis is the branch of mathematics which provides the bridge between analysis as practised by mathematicians and the finite arithmetic used by computer hardware. The Fields thematic program, Numerical and Computational Challenges in Science and Engineering, focused upon the development of new numerical methods to exploit the power of a new generation of high-performance and often massively parallel computers.

The program featured a series of workshops on several key application areas including climate modelling, computational biology, computational finance, and computer animation, as well as exploring the exciting new area of interaction between symbolic and numeric computation.

A more complete description of the program and of events up to July 2002 may be found in the Fields Institute Annual Report (2002).

The thematic program on Numerical and Computational Challenges in Science and Engineering concluded its year of activities with the following events, which took place after July 1, 2002.

### COURSE

**Short Course on Numerical Solution of Advection-Diffusion-Reaction Equations**  
July 29–August 2, 2002  
Instructors: Martin Berzins (Leeds) and Jan Verwer (CWI, Amsterdam)

### WORKSHOPS

**IMACS Workshop on Adaptive Methods for Partial Differential Equations**  
August 6–9, 2002  
Organizers: Paul Fischer (Argonne National Laboratories), Joseph E. Flaherty (Rensselaer), Benqi Guo, Co-chairman (Manitoba), Kenneth R. Jackson, Co-chairman (Toronto), Robert D. Russell (Simon Fraser)

### CONFERENCES

**Symbolic and Numeric Computation in Geometry, Algebra, and Analysis**  
July 15–19, 2002  
Held at the University of Western Ontario  
Organizers: Robert Corless (UWO), Edward Green (Virginia Tech), Serkan Hosten (SFSU), Reinhard Laubenbacher (Virginia Bioinformatics Inst.), Victoria Powers (Emory), Greg Reid (UWO)

**McMaster Optimization Conference**  
August 1–3, 2002  
Held at McMaster University  
Organizers: Stavro Kollipoulos (McMaster), Tom Luo (McMaster), Jiming Peng (McMaster), Tamás Terlaky, Chair (McMaster), Henry Wolkowicz (Waterloo)

### SEMINAR

**July 31, 2002**  
John T. Betts (Boeing Company)  
Computing Aerodynamic Models Using Large-scale Parameter Estimation

**Short Course on Numerical Solution of Advection-Diffusion-Reaction Equations**  
July 29–August 2, 2002  
Instructors: Martin Berzins (Leeds) and Jan Verwer (CWI, Amsterdam)

The course introduced an audience of twenty academics and postgraduate students to fundamental concepts and
research topics in the numerical solution of advection-diffusion-reaction equations. The topics ranged from an appreciation of the underlying physical problems to numerical methods in ordinary and partial differential equations for ensuring that meaningful physical solutions to these problems are computed. The o.d.e. methods considered encompassed implicit-explicit time integration methods (IMEX), positivity-preserving o.d.e. methods, and Runge-Kutta schemes with extended stability regions. The spatial discretization methods included modern finite volume and finite element schemes and incorporated a brief survey of state-of-the-art research in such areas as, for example, discontinuous Galerkin methods.

WORKSHOPS

IMACS Workshop on Adaptive Methods for Partial Differential Equations
August 6–9, 2002
Held at the McLennan Physical Labs, University of Toronto
Sponsored by IMACS and the Fields Institute
Organizers: Paul Fischer (Argonne National Laboratories), Joseph E. Flaherty (Rensselaer), Benqi Guo, Co-chairman (Manitoba), Kenneth R. Jackson, Co-chairman (Toronto), Robert D. Russell (Simon Fraser)
Adaptive methods for partial differential equations are the most effective computational approach for a large class of PDEs that arise in many important applications in science and engineering. This area has grown steadily in the past two decades. The workshop brought together researchers from around the world to address both theoretical and computational aspects of adaptive methods for PDEs and to foster stronger collaboration among mathematicians, engineers, and scientists. Ninety-eight participants attended. In addition to the plenary talks, thirty-four speakers gave short invited presentations.

Plenary Speakers:
Mark Ainsworth (Strathclyde)
Hp-finite Element Methods for Maxwell’s Equations
Ivo Babuska (Texas–Austin)
Adaptivity Problems in the Solution of Stochastic PDEs
Randy Bank (UC–San Diego)
1. Asymptotically Exact A Posteriori Error Estimators for General Unstructured Grids
2. Superconveyance and Asymptotically Exact A Posteriori Error Estimates

Martin Berzins (Leeds)
Computational Engineering Challenges for Adaptive Mesh Refinement

Anne Bourlioux (Montréal)
Some Adaptive Strategies in Turbulent Combustion

Bernardo Cockburn (Minnesota)
Adaptivity and A Posteriori Error Estimation for Hamilton-Jacobi Equations

Leszek Demkowicz (Texas–Austin)
Fully Automatic Hp-adaptive Simulations

Yvon Maday (Université Pierre et Marie Curie)
A Posteriori Bounds on Outputs: Applications to Finite Element and Reduced Basis Approximations

Oleg Vasilyev (Missouri–Columbia)
Adaptive Wavelet Collocation Method for the Solution of Partial Differential Equations

Junping Wang (Colorado School of Mines)
Interior Estimates of Superconvergence for Finite Element Solutions by Local Projections

Workshop on the Solution of Partial Differential Equations on the Sphere
August 12–15, 2002
Organizers: John Drake (Oak Ridge National Laboratory), Kenneth R. Jackson (Toronto), Paul Swarztrauber (National Center for Atmospheric Research), David Williamson (National Center for Atmospheric Research)
The theme of the workshop was the development of new solution methods for fluid flow in spherical geometry. In attendance were representatives from most of the major international climate and meteorological research centres along with university researchers and graduate students. Such broad participation allowed those present to have previews of operational plans and of the most promising developments in the use of innovative gridding techniques, high-order methods, and conservative transport algorithms. Timely results using the impressive computational power of the Japanese Earth Simulator were shown for several numerical methods. New ways of eliminating shortcomings in current procedures for addressing the problems unique to spherical geometry were demonstrated by application to the shallow-water equations and to complete baroclinic models. The workshop is the fourth in an annual series.

One session was devoted to the definition of new test cases that will elucidate convergence of baroclinic models.

Thematic Programs

Martin Berzins (Leeds)
Computational Engineering Challenges for Adaptive Mesh Refinement

Anne Bourlioux (Montréal)
Some Adaptive Strategies in Turbulent Combustion

Bernardo Cockburn (Minnesota)
Adaptivity and A Posteriori Error Estimation for Hamilton-Jacobi Equations

Leszek Demkowicz (Texas–Austin)
Fully Automatic Hp-adaptive Simulations

Yvon Maday (Université Pierre et Marie Curie)
A Posteriori Bounds on Outputs: Applications to Finite Element and Reduced Basis Approximations

Oleg Vasilyev (Missouri–Columbia)
Adaptive Wavelet Collocation Method for the Solution of Partial Differential Equations

Junping Wang (Colorado School of Mines)
Interior Estimates of Superconvergence for Finite Element Solutions by Local Projections
and the growth of instabilities after imposing specified perturbations. Plans were made for reporting results in order to clarify outstanding issues.

The informal nature of the workshop along with the excellent Fields facilities fostered interesting debates and discussions. Of greater significance, it stimulated a number of collaborations and drew several groups into closer contact for attacking common problems in the future.

**Speakers:**

- Jorn Behrens (Technische Universität München)  
  *Achieving Mass Conservation in Adaptive Semi-Lagrangian Advection Schemes*

- Luca Bonaventura (Max-Planck Institute for Meteorology, Hamburg)  
  *Project for the Development of a Nonhydrostatic Dynamical Core for Climate and NWP Simulation*

- John P. Boyd (Michigan)  
  *A Comparison of the Rate of Convergence, Efficiency, and Condition Number of Chebyshev and Legendre Polynomial Series with Prolate Spheroidal, Kosloff/Tal-Ezer, and Theta-mapped Fourier Basis*

- Elisabetta Cordero (Met Office)  
  *Normal Mode Analysis of the “New Dynamics” Discretization Employed at the Met Office*

- J. Coté (Meteorological Service of Canada)  
  *A Fractional Steps Method for the Numerical Solution of the Shallow-water Equations*

- Terry Davies (Met Office, Bracknell, U.K.)  
  *Three-dimensional Test Problems for Global Atmospheric Models*

- A. Fournier (Maryland)  
  *Multi-resolution Adaptive Spectral Elements: Application to Shallow-water Flow on the Sphere*

- Francis X. Giraldo (Naval Research Laboratory)  
  *A Spectral Element Semi-Lagrangian Atmospheric Model (SESLLAM)*  
  *A Scalable Spectral Element Eulerian Atmospheric Model (SEE-AM): Dynamical Core Tests*

- Daniel Guo  
  *Smooth Grid Transformations with Spectral Methods for the Shallow-water Equations*

- Thomas Heinze (Technische Universität München)  
  *A Close Use to Test Case 5*

- Christiane Jablonowski (Michigan)  
  *New Idealized Test Cases for Dynamical Cores*

- Eigil Kaas (Danish Meteorological Institute)  
  *An Accurate Cell-integrated Semi-Lagrangian and Semi-implicit Scheme Based on Step-functions*

- Oswald Knoth (Institute for Tropospheric Research)  
  *A Nonhydrostatic Anelastic Model with a Cut Cell Approach and Implicit Time Stepping*

- Anita Layton (North Carolina)  
  *A Semi-Lagrangian Double Fourier Method for the Shallow-Water Equations*

- L.M. Polvani (Princeton)  
  *An Initial-value Test Case for Dynamical Cores of Atmospheric General Circulation Models*

- Joseph M. Prusa (Iowa State)  
  *Continuous Dynamic Grid Adaptation in a Global Atmospheric Model*

- Janusz Pudykiewicz (Meteorological Service of Canada)  
  *Numerical Simulation of Reactive Flow in Spherical Geometry*

- Abdessamad Qaddouri (Meteorological Service of Canada)  
  *Parallel Elliptic Solvers for the GEM Model*

- David A. Randall (Colorado State)  
  *Impact of an Energy-Conserving Scheme in the CSU Geodesic-Grid AGCM*

- Masaki Satoh (Saitama Institute of Technology, Japan)  
  *Conservative Scheme for a Non-hydrostatic Climate Model*

- Reiji Suda (Nagoya University)  
  *Fast Spherical Harmonics Transform of FLTSS and Its Evaluation*

- Steve Thomas (National Center for Atmospheric Research)  
  *An Overlapping Additive Schwarz Pre-conditioner for the Cubed-sphere*

- Motohiko Tsugawa (Saitama Institute of Technology, Japan)  
  *Development of a Global Ocean Model on Quasi-homogeneous Cubic Grid*

- Agathe Untch (ECMWF)  
  *Tests with Cubic Spline Interpolation in the Vertical Advection of the ECMWF Semi-Lagrangian Model in Connection with a Cubic Finite-element Discretization in the Verticals*

- Nigel Wood (Met Office)  
  *A Framework for the Analysis of Physics-dynamics Coupling Strategies*
K.S. Yeh (NASA Goddard Space Flight Center)  
*Variable-resolution Finite-volume General Circulation Model*

Hiroshi Yoshida (Tokyo Institute of Technology)  
*Shallow-water Equations in Spherical Geometry Solved by a High-accurate IDO Scheme and Overset Grid*

**Workshop on the Mathematics of Computer Animation**  
November 8–9, 2002  
Organizers: Karan Singh and Wayne Enright (Toronto)

The workshop on the Mathematics of Computer Animation brought together representatives from a number of leading computer graphics research labs (CMU, Brown, Rutgers, Ohio State, UBC, Berkeley, and Toronto), participants from leading animation software companies (Alias|wavefront and Side Effects), and animator/director Chris Landreth (Sentient Ltd).

A major theme was the use of data acquired from the real world in the synthesis of computer animation. These data range from the geometric shape of objects and their physical attribute information to the capture of their motion trajectories. A number of problems of importance were discussed: the organization and data-mining of captured information for animation synthesis; the retargeting of captured data across different models; and the integration of data driven approaches with the more traditional animation approaches of key-framing and physical simulation.

Expressive facial animation was discussed, particularly the mathematical challenges in modelling realistic faces. The desire to quantify emotion as something that could be modelled, validated, and quantified mathematically was the subject of lively debate.

**Speakers:**  
Wayne Enright  
*Fast Visualization/Animation of Approximate Solutions of PDEs*

Jessica Hodgins (CMU)  
*Animating Human Characters*

James Kuffner (CMU)  
*Task-level Character Motion Synthesis as High-dimensional Search*

Chris Landreth  
*Realism and Psychology in Animation*

Raghu Machiraju (Ohio State)  
*Synthesis and Animation through Analysis of Data*

Dinesh Pai (Rutgers)  
*Multisensory Interactive Animation*

Rick Parent (Ohio State)  
*Lip-sync Animation*

Nancy Pollard (Brown)  
*Animating Manipulation Tasks from Human Motion Data*

Mike van de Panne (UBC)  
*Haptic Control Envelopes and Other Unfinished Projects*

**CONFERENCES**

Symbolic and Numeric Computation  
in Geometry, Algebra, and Analysis  
July 15–19, 2002  
Held at the University of Western Ontario  
Organizers: Robert Corless (UWO), Edward Green (Virginia Tech), Serkan Hosten (SFSU), Reinhard Laubenbacher (Virginia Bioinformatics Inst.), Victoria Powers (Emory), Greg Reid (UWO)

Topics in the special meeting included coding theory, geometric invariant theory, and the interaction between symbolic-numeric computation and computational algebra. In addition to the invited one-hour talks listed below, there were twenty half-hour talks.

The conference was supported by the Fields Institute and by the U.S. National Science Foundation.

**Invited speakers who gave one-hour addresses:**  
Alicia Dickenstein (Buenos Aires)  
*The Beautiful World of A-discriminants*

Karin Gatermann (FU, Berlin)  
*Toric Geometry and Dynamics of Chemical Reactions*

Arieh Iserles (Cambridge)  
*Computing the Exponential in a Lie Algebra*

Gregor Kemper (München)  
*An Introduction to Computational Invariant Theory*

George Labahn (Waterloo)  
*Fraction-free Arithmetic with Systems of Linear Differential Operators*

Peter Olver (Minneapolis)  
*Moving Frames for Pseudo-groups*
Lorenzo Robbiano (Genova)
*Commutative Algebra and Statistics*

Joachim Rosenthal (Notre Dame)
*Public Key Cryptography and Semi-group Actions*

Frank Sottile (Massachusetts)
*Common Transversals and Tangents*

Jan Verschelde (UIC)
*Symmetric Functions Applied to Decomposing Solutions of Polynomial Systems*

**McMaster Optimization Conference**

August 1–3, 2002

Held at McMaster University

Organizers: Stavro Kolliopoulos (McMaster), Tom Luo (McMaster), Jiming Peng (McMaster), Tamás Terlaky, Chair (McMaster), and Henry Wolkowicz (Waterloo)

The McMaster Optimization Conference: Theory and Applications (MOPTA 02) was hosted by the Advanced Optimization Laboratory, Department of Computing and Software, McMaster University. In the MOPTA tradition, the organizers’ goal was to bring together researchers from diverse areas of theoretical and applied optimization in a medium-size conference.

Following the technical program, there was a banquet at Lasalle Park in Burlington, which featured an after-dinner presentation by Stephen Boyd (Stanford), *Circuit Designers, Interior Point Methods, and Venture Capitalists.*

MOPTA 02 was generously sponsored by the McMaster Faculty of Engineering, the Fields Institute as a part of the thematic program on Numerical and Computational Challenges in Science and Engineering, MITACS, Materials and Manufacturing Ontario, and IBM Canada.

**Invited Speakers:**

John Betts (Boeing)
*An Optimal Low-Thrust Trajectory to the Moon*

Stephen Boyd (Stanford)
*Optimal Design of Analog Circuits via Geometric Programming*

C.A. Floudas (Princeton)
*Deterministic Global Optimization: Advances and Challenges*

Robert Freund (MIT)
*Computational and Theoretical Perspectives on Complexity for Linear, Conic, and Non-conic Convex Optimization*

Aravind Srinivasan (Maryland)
*Incremental Randomization in Combinatorial Optimization*

Richard Tapia (Rice)
*Interpreting the Classical Inverse Shifted Inverse, and Rayleigh Quotient Iteration Methods as a Standard Formulation of Newton’s Method from the Nonlinear Programming Literature*

Yinyu Ye (Stanford)
*Improved Complexity Results on Solving Real-Number Linear Feasibility Problems*

**SEMINAR**

John T. Betts (Boeing Company)
*Computing Aerodynamic Models Using Large-Scale Parameter Estimation*

July 31, 2002

The differential or differential-algebraic equations arising from a physical problem often have a finite number of parameters which have to be estimated from observations of the system dynamics. One approach to this “inverse problem” is to discretize the dynamics and then treat the values at mesh points as optimization variables, leading to a nonlinear programming problem. This is known as the direct transcription method. Since the Hessian and Jacobian matrices are sparse, very efficient techniques from linear algebra can be applied. John Betts described a quadratically convergent algorithm for estimating parameters and illustrated the method by showing the way in which it can be used to construct aerodynamic models from flight test data.

Organizer: George A. Elliott  
(Fields Institute and University of Toronto)

The Operator Algebra thematic program began in 1996 and has continued since then. This year, a working research seminar, mainly concerned with questions related to the structure and classification of amenable C*-algebras, met most Tuesday and Wednesday afternoons. Every second week during term, the Ontario Non-commutative Geometry Seminar, co-organized with Masoud Khalkhali (Western), was held. In addition—together with A. Connes (Collège de France), J. Cuntz (Münster), and B. Tsygan (Northwestern)—Elliot and Khalkhali ran a workshop on non-commutative geometry, April 5–10, 2003, at the Banff International Research Station.

During the year, the following five postdoctoral fellows were active in the program: Xiaodong Hu, Hanfeng Li, Peter Miegom, Hideki Nakamura, and Ping Wong Ng. There were also fourteen graduate students involved: PhD students—Kristofer Coward, Guangyu Fu, Cristian Ivanescu, Zhuang Niu, Brian Pigott, Lionel Robert, Andrew Toms, and Kin Wai Tsang; MSc students—Mark Braverman, Chris George, and Brian Lee; NSERC Research Assistants—Michael Bailey, David Bland, and Meghyn Garner.

From June 21 to July 20, 2003, a Summer Operator Algebra Workshop was held at the Fields Institute, with Ola Bratteli (Oslo) and Akitaka Kishimoto (Hokkaido) visiting during that time. The main object of study during this workshop was one-parameter automorphisms of amenable C*-algebras.

As an offshoot of the program, twenty-three high school students were supervised during weekly meetings under the auspices of the University of Toronto Arts and Science Mentorship Program: co-ordinator, Leonel Robert; mentors, Josée Bilodeau, Kristofer Coward, Arthur Fischer, Cristian Ivanescu, Hanfeng Li, and Brian Pigott.
In the third lecture, recent work of E. Lindenstrauss was described. This concerns the following conjecture: let $M$ be a compact Riemannian manifold of negative curvature. Then, any sequence of eigenfunctions $\varphi_i$ of the Laplacian (normalized to have $L^2$-norm 1) with eigenvalues $\lambda_i$ tending to $-\infty$ has the property that

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

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

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

Distinguished Lecture Series in Statistical Science
Donald A. Dawson
Probabilistic Phenomena in Mathematics and Science
April 23 and 24, 2003

The second annual Fields Distinguished Lecture Series in Statistical Science was given by a former Director of the Fields Institute (1996–2000), D.A. Dawson. His two talks were together entitled Probabilistic Phenomena in Mathematics and Science.

In his second lecture, Sarnak explained how ideas from ergodic theory and mathematical physics have inspired some recent work in the study of equidistribution of eigenfunctions of the non-Euclidean Laplacian.
Donald Dawson 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 is one of Canada’s most respected mathematicians. His talks provided a masterful survey of the history, basic themes, and recent developments in modern probability theory, focusing on unifying features and on the way in which related probabilistic ideas spring up in a host of different contexts and applications.

One of those unifying ideas is universality—the observation that broad classes of objects seem to share the same interesting limit, which can often be identified as a fixed point of some scaling transformation. The best-known example is the Central Limit Theorem, which has the Gaussian or Normal distribution as its limiting object. Brownian motion arises in the same way, through Donsker’s theorem, as a fundamental object in the study of stochastic processes, again having a kind of invariance under scaling. But other related examples were described, starting with Benford’s law for random digits. An exciting recent instance is Wigner’s semicircle law for the eigenvalues of random matrices, and its apparent connection to the Riemann zeta function. Another is the presence of conformal invariance in such new discoveries as the stochastic Loewner equation. Dawson described how these fundamental limits are used to construct and study related but less symmetric objects—for example, the use of Brownian motion to construct Markov processes via the Ito Calculus (and so on to the Black-Scholes-Merton formula for option pricing).

In analogy to the basic Markov property, one can study local dependence structures or interactions for more general random fields (e.g., the Brownian sheet), or for spatially distributed stochastic systems such as percolation and the Ising model. That way lie interesting questions such as universality in statistical physics, and from the critical branching and coalescing structures that arise in genetics and in population biology. An example of the latter is super Brownian motion, known justifiably to an earlier generation as the Dawson-Watanabe process, and fundamental to the study of stochastic partial differential equations. This model was used to illustrate recent interest in topics such as hierarchy, genealogy, and interaction.

The breadth and range of the topics presented were breathtaking, as was the way the speaker brought out common threads tying them all together. A distinguished series of lectures, indeed!
In the 1830s, Dirichlet generalized Euclid’s result in a deep way to establish that there are infinitely many primes in any arithmetic progression \(\{a + dn : n \geq 0\}\) provided that \(\gcd(a,d) = 1\). In doing so, he used generalizations of the zeta function, now called Dirichlet series.

Modern analysis of primes has focused on generalizing Dirichlet’s theorem to much more general and thinner sequences. Selberg was a main force in systematizing the sieve method and establishing criteria for effective sieves to yield a computation of primes in sequences. Friedlander and Iwaniec added some significant refinements to this method in order to establish that the number of primes of the form \(a^2 + b^4\) which are less than \(x\) is of the order of \(cx^{3/4}/\log x\). This was a major breakthrough, as no estimates had previously been obtained for any sequence which was so thin.

Friedlander concluded his talk with the hope that improvements in these methods will eventually solve problems such as the twin prime conjecture and the \(n^2 + 1\) problem.

**CRM-Fields 2003 Prizes**

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. Recipients are 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.

The joint winners of the 2003 CRM-Fields Prize are John McKay and Edwin Perkins, who will deliver lectures in October 2003.

**John McKay (Concordia)**

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

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

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

**Edwin Perkins (UBC)**

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

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

**Special Lecture**

**Manindra Agrawal**

*A Polynomial-time Algorithm for Primality Testing*

May 23, 2003

The world of theoretical computer science was startled in August 2002 when a deterministic polynomial-time algorithm for primality was announced. It is due to Manindra Agrawal (Indian Institute of Technology, Kanpur)
Manindra Agrawal and Kenneth Davidson

together with two undergraduates working under his direction, Neeraj Kayal and Nitin Saxena. Agrawal gave a very clear and succinct presentation of this important breakthrough to a packed audience at the Fields Institute on May 23.

Algorithms to test whether a number is prime have been of interest to number theorists for centuries, but have recently become of practical interest, since, for example, the RSA algorithm for public-key cryptography depends on having available two large primes whose product forms the key. Agrawal began by outlining earlier work on the problem. The general problem here is to test whether a number $N$ expressible using $n$ binary digits is prime or not. The brute force approach of the sieve of Eratosthenes, trying all divisors up to $\sqrt{N}$, takes time exponential in $n/2$.

A subtler approach is to use Fermat's little theorem, which says that for any prime $p$, $a^p \equiv a \mod p$ for any $a$. Unfortunately, this approach runs into trouble, since there are also composite $p$ (Carmichael numbers) such as 561 satisfying the congruence above for all $a$.

In 1973, Gary Miller adapted the Fermat test to show the existence of an algorithm running in time $n^4$, but its correctness depended on the Extended Riemann Hypothesis. Michael Rabin shortly after showed how the ERH could be replaced by a source of random numbers, to give a fast randomized algorithm that could produce numbers certified as prime to any desired degree of certainty. The fastest, known, randomized algorithm of this kind is that of Adleman, Pomerance, and Rumely (1983) running in time $n^{\log \log n}$. Agrawal remarked that since for all practical purposes, $\log \log n \leq 4$, the problem of testing large numbers for primality can be considered as solved, in a practical sense. Nevertheless, in spite of these positive results, the problem of providing a truly polynomial-time, deterministic algorithm remained.

It was here that Agrawal, Keeraj, and Saxena had a simple but brilliant new idea. The main innovation is to generalize Fermat's Little Theorem to a more tractable space, the space of polynomials $P(X)$ modulo $N$ and $X^r - 1$, for suitable "small" $r$. A generalization of the Fermat theorem to this new space is not hard to prove, and leads to the new algorithm. It can be written down in a few lines of pseudo-code, and involves testing the number $N$ with respect to only a few instances of the generalized Fermat equation (some auxiliary tests are necessary to rule out some special cases). The proof of correctness is remarkably easy and straightforward, and its presentation, virtually complete, concluded Agrawal's beautiful talk.

Special Lecture
Florin Diacu

*Newton + Einstein = Manev*

December 6, 2002
Organizer: Chandler Davis (Toronto)

In the 1930s, the Bulgarian physicist Georgi Manev suggested the use of a gravitational law similar to the Newtonian one but with a correction term. His work passed unnoticed until it proved to succeed where the classical law had failed: in predicting the perihelion advance of Mercury. In the first part of his talk, Florin Diacu (PIMS and the University of Victoria) analysed Manev's two-body problem, proved that the correction term can be derived from general relativity, and revealed that Newton had already considered using this gravitational law instead of the inverse square one, but for reasons very different from those of Manev. In the second part, Diacu introduced the anisotropic Manev problem, which lies at the intersection of classical, quantum, and relativistic mechanics, and presented some of its local and global dynamical properties.
Public Lecture
Stuart Whittington
Random Knotting
January 26, 2003
Held at the University of Toronto

Sponsored by the Royal Canadian Institute
and the Fields Institute

Founded in 1849 to promote the advancement of science, the Royal Canadian Institute for many years has held a series of Sunday afternoon public lectures at the University of Toronto. The Fields Institute has agreed to make talks on mathematics a regular part of the public lecture series. At the first such mathematics lecture, Stuart Whittington, an applied mathematician in the Chemistry Department at the University of Toronto, spoke on Random Knotting.

The theme of the lecture was that long flexible objects— for example, string, garden hoses, and long molecules such as DNA—tend to get knotted and entangled. We observe this in everyday activities; biochemists see this in molecules which are fattened up with a protein batter and filmed under an electron microscope.

Having both practical and decorative uses, knots have fascinated people for many centuries and have been studied by mathematicians during the past hundred years. A serious question is to decide whether two knots are the “same,” i.e., by twisting and rearranging one knot without cutting it, can it be deformed into the other? And how can you tell if a string is actually knotted at all? The latter question is often easier because a knot in one part of the string means that the whole string is non-trivially knotted. One way to catalogue knots is to enumerate them by considering a representation with the minimal number of crossings when laid out on a flat surface. Determining this number can be a challenge.

Other properties of knots are twists and writhes. A strand of string or hose can be twisted around many times. If the ends are held but moved closer together, the string will change shape with a section of twisted string pushing out from the main strand. This is called a “writhe.” A quantitative measurement of twist and writhe can be made, and an old result known as White’s Theorem says that the sum of the twist and writhe of a knot is constant.

Whittington provided a number of interesting examples of knots and writhes in nature, particularly in DNA, and described the active collaboration between molecular biologists and applied mathematicians in studying knots in large molecules.
Fields Annual General Meeting
June 12, 2003
Activities began with an information session for sponsors and affiliates of the Institute and necessary formal business meetings. In their meeting, the Board of Directors named seven new Fields Institute Fellows for 2003, who were recognized for their distinguished contribution to mathematics in Canada and to the Fields Institute: Gila Hanna (OISE, University of Toronto); Anna Lawniczak (University of Guelph); John McKay (Concordia University); Kumar Murty (University of Toronto); Edwin Perkins (University of British Columbia); William Pulleyblank (IBM); and Nancy Reid (University of Toronto).

By recent tradition, the AGM also includes public lectures. This year, there were talks by Juris Steprans of York University on Set Theory and Its Impact on Analysis, and by Raymond Laflamme, Director of the Institute for Quantum Computing at the University of Waterloo, and a member of the Perimeter Institute for Theoretical Physics, who spoke on Quantum Computing. A reception followed, and dinner at the University of Toronto Faculty Club included an after-dinner talk by Moshe Milevsky, Director of the IFID Centre (housed at the Fields Institute) and a faculty member of the Schulich School of Business at York University.

Juris Steprans began with the origins of the use of set theoretic techniques in analysis, which go back to Cantor in his investigations of sets of uniqueness for trigonometric series. Set theory has also played an important role in measure theory, for example, in the construction of non-measurable sets. The relationship between set theory and analysis languished for some time until a renaissance about thirty years ago, beginning with the realization that measurability and other regularity properties of sets were connected with the theory of large cardinals and generic reals over inner models.

In the 1950s, H. Steinhaus asked if there was a subset $S$ in $\mathbb{R}^2$ for which $|S \cap L| = 1$ for every isometric copy $L$ of the lattice $\mathbb{Z}^2$. This question was finally answered in the affirmative last year by S. Jackson and D. Mauldin, using a clever induction strategy combined with an analysis of mechanical linkages, Gröbner bases, and some intricate number theory. There are many open questions of this
nature: for example, is there a Borel set in the plane meeting each line in precisely two points?

A now classical application of Ramsey theory to Banach spaces is H. Rosenthal’s theorem which characterizes Banach spaces that contain a copy of $l_1$. More recently W.T. Gowers used infinite-dimensional Ramsey theory in his contribution to solving the homogeneous space problem of Banach: a Banach space which is isomorphic to all of its infinite dimensional subspaces is isomorphic to a Hilbert space. Further examples of theorems in Banach spaces with a strong set-theoretic flavour were given.

Raymond Laflamme began his talk on Quantum Computing with a brief history of computing, beginning in 1870 with Babbage’s Analytical Engine. The possibility of computing with quantum mechanics occurred to Benioff in 1980, followed soon after by the realization of Feynman and Deutsch that quantum computers could be much faster than their classical counterparts.

Laflamme pointed out that “Moore’s Law”—which states that transistor performance doubles every three years—will necessarily soon be violated, as current progress in hardware is rapidly approaching the barriers defined by the laws of quantum physics. Quantum computation attempts to short-circuit that constraint by exploiting the quantum laws to advantage rather than regarding them as obstacles.

A quantum computer would accept any superposition of its inputs as an input, processing the components simultaneously. This quantum parallelism allows one to explore exponentially many trial solutions with relatively modest means, and to select the correct one. It has a particularly dramatic effect on the factoring of large integers, the core of many current encryption strategies. Quantum computers can render this encryption protocol obsolete. Whereas classical methods of computing can factor a composite number whose binary representation involves $L$ bits with approximately $\exp(A(L^{1/3} \ln L)^{2/3})$ operations, the quantum factoring method introduced by Peter Shor in 1994 requires only $L^{3/2}$ operations. It is now understood that quantum computation can lead to many computational breakthroughs, in coding as well as in other areas.

Quantum computing is not only about increasing the clock time of a processor from 10GHz to 100 or 1000 GHz, but it is a fundamentally different way of manipulating information, with a new set of rules that question our basic understanding of information and of complexity theory.

Today we are witnessing the birth of a new science which has the potential of enormous technological impact.

Among the distinguished guests at the AGM evening banquet were Solange Belluz, senior policy analyst of the Ontario Ministry of Training, Colleges, and Universities; John Crow, former Governor of the Bank of Canada, and newly appointed member of the Fields Institute; Sheila Embleton, Vice-President Academic at York University; and the Honourable Roy McLaren P.C., a former federal cabinet member (Trade, Finance, and National Revenue) and Canadian High Commissioner to the U.K.

In his lively after-dinner talk, Moshe Milevsky gave several examples of silly investment strategies, using them to describe ways in which even very elementary mathematics can be applied effectively in financial considerations to avoid some of the pitfalls of investing. He argued that much investment advice is grounded in faulty logic or questionable data and is often tainted by subtle conflicts of interest.

Fields Director Ken Davidson wished the five local members of Canada’s International Math Olympiad team who attended the banquet all the best in their forthcoming competition. Dinner closed with a warm tribute by Ken to Bradd Hart, whose term as Deputy Director of the Institute ended July 31, 2003.

**Graduate School Information Day**
November 2, 2002

The Fields Institute held its second Graduate Information Day on Saturday November 2, 2002. Representatives from Guelph, McMaster, Ottawa–Carleton, Toronto, Waterloo, Western, and York were on hand and provided pamphlets and helpful advice about grad school. Memorial University of Newfoundland was unable to have a representative present, but provided application packages.
Following a format similar to last year’s successful event, the Institute scheduled two talks on areas of interest to upper-year undergraduates. Students found the talks enlightening and at an appropriate level, and several of them indicated an interest in pursuing further research on these topics. Students also commented on the hospitality of the Fields Institute and noted the value of having access to information about numerous graduate programs in one location.

The first talk, *From Symmetric to Quasi-symmetric*, was given by N. Bergeron (York). Several common bases of polynomials were considered, including the homogeneous polynomials and Schur polynomials, with emphasis on the elementary symmetric polynomials. Connections were drawn to quantum mechanics (where observables are represented by symmetric matrices) as well as to Temperley-Lieb algebras and Hopf algebras.

The second talk, *From Games to Numbers and Beyond*, by D. Christensen (Western), was a discussion of numbers in game theory. He introduced the game of Hakenbush and the idea of the value of a game, a quantification of the advantage one player has over the other. Additional games such as Nim, Toads and Frogs, and Col were also described. Certain games were discovered to have a surprising array of values. Not limited even to the rationals, some games had infinitesimal values or evidenced other odd behaviour.

During the break, the approximately sixty undergraduates who attended the event discussed graduate school and mathematics with the professors present. Math continued even on the bus ride home, as students from Waterloo played a game of Col.

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**New Fellows of the Royal Society of Canada**

*October 19, 2002*

On Saturday October 19, 2002, four newly elected fellows of the Academy of Science of the Royal Society of Canada gave stimulating talks at the Fields Institute about their work, followed by good questions and conversation. Joint hosts for the occasion were Cameron Stewart, RSC director for the Mathematical and Physical Sciences Division, and Kenneth R. Davidson, Director of the Fields Institute.

**FRSC Speakers:**

Peter Guthrie (Western)
*Predicting How Fast a Chemical Reaction Will Occur*

Niky Kamran (McGill)
*Wave Equations in Kerr Geometry*

Neal Madras (York)
*Self-Avoiding Walks and Related Models*

Vidyadhar Godambe (Waterloo)
*A Fundamental Paradox of Statistics*
Workshops

**Nonselfadjoint Operator Algebra Workshop**  
July 8–12, 2002  
Organizer: Kenneth R. Davidson (Fields Institute)

In July 2002, Ken Davidson ran a workshop in his own specialty area, (nonselfadjoint) operator algebras. The reason for the adjective “nonselfadjoint” is that in some circles, the term “operator algebras” has been cornered by the C*-algebraists. However, the group claiming “operator algebras” for arbitrary algebras of bounded operators on Hilbert space is growing. This area has close links to operator theory (which studies operators one or three at a time) and the developing area of operator spaces (which develops functional analytic ideas in a context where there are norms on all matrix spaces over the algebra).

In addition to two dozen registrants, local mathematicians joined the workshop, bringing the number of participants to thirty. Speakers came from the U.K., Greece, and Israel as well as the U.S.A. and Canada.

The twenty-three talks were scheduled for mornings or late afternoon, leaving plenty of time during early afternoons and evenings for small groups of people to collaborate. Indeed, the talks were just catalysts for the real work which happened in free-wheeling conversations in the afternoons and evenings.

**Tenth International Conference on Representations of Algebras and Related Topics (ICRA)**  
July 15–August 10, 2002  
Local organizers: S. Berman (Saskatchewan), Y. Billig (Carleton), R.-O. Buchweitz (Toronto), V. Dlab (Carleton), S. Liu (Sherbrooke), E. Neher (Ottawa)

Held at the Koffler Institute for Pharmacy, Toronto

The biennial international conference, first held in 1974 in Ottawa, returned to Canada for its tenth instalment.

It opened with an instructional workshop (July 15–20) for graduate students and young researchers on recent developments in the representations of algebras and their applications. There were eight lecture series on the following topics: applications of representations of algebras in probability theory (K. Brown, Cornell); a survey of results in the theory of tame algebras (T. Brüstle, Bielefeld); the application of representations of weighted projective lines to the Deligne-Simpson problem for local monodromy of differential equations (W. Crawley-Boevey, Leeds); the use of semi-invariants of quiver representations culminating in an elegant proof of the saturation of Littlewood-Richardson coefficients (H. Derksen, Michigan); the recent solution of long-standing conjectures by M. Auslander on representation dimension and by Solomon on Euler factors of ζ-functions of lattices (O. Iyama, Kyoto); a complete description of representations of the symmetric groups and affine Hecke algebras and their branching rules in positive characteristic via crystal bases (A. Kleshchev, Oregon); the use of filtrations and stratifications in the representation theory of Lie algebras (S. Koenig, Leicester); an exposition of results on representations and Hecke-Iwahori algebras of reductive monoids (M. Putcha, NC State, and L. Renner, Western). The lectures were well attended by graduate students from many different countries.

Following the workshop, the conference took place (July 22–31), with more than eighty talks covering the whole range of representations of algebra.
The third part of ICRA 2002 consisted of the following three interwoven specialized workshops:

**Commutative Algebra, Algebraic Geometry, and Representation Theory.**
Organizers R.-O. Buchweitz; W. Crawley-Boevey; and Y. Drozd (Kiew)

**Finite Dimensional Algebras, Algebraic Groups and Lie Theory.**
Organizers: E. Neher; L.L. Scott (Virginia)

**Quantum Groups and Hall Algebras.**
Organizers: S. Berman; C.-M. Ringel (Bielefeld)

There were also two survey lecture series: one by K. Rietsch (Oxford) and Y. Saito (Tokyo), who covered, in an introduction to perverse sheaves and canonical bases, Lusztig’s geometric construction of bases for affine Kac-Moody and Ringel-Hall algebras; and the other by Y. Drozd, who gave an overview of the classification of vector bundles and Cohen-Macaulay modules on surfaces and curves.

The proceedings will appear in the Fields Communications Series early in 2004.

**Workshop on Geometry, Mechanics, and Dynamics in Honour of the Sixtieth Birthday of J.E. Marsden**
August 7–10, 2002
Organizing committee: P. Newton (USC), Chair, A. Bloch (Michigan), T. Ratiu (EPFL, Lausanne), S. Shkoller (UC Davis), A. Weinstein (Berkeley)

The Fields Institute held a celebration to mark the sixtieth birthday of Jerrold E. Marsden (Caltech), the Institute’s founding director. With one hundred and fifty people in attendance and many fine talks, it was a great success both scientifically and socially.

The workshop was organized around the seven main themes of Marsden’s work: geometric mechanics; fluid mechanics; elasticity and analysis; numerical algorithms; relativity and quantum mechanics; geometric control theory; and dynamical systems. The common thread throughout Marsden’s work is his use of geometric methods to unify diverse disciplines, enabling a wide variety of scientists and mathematicians to speak a common language, and thereby encouraging cross-fertilization. Jerry Marsden is a unique figure in this regard, as his work has significantly influenced the three distinct communities of mathematicians, physicists, and engineers.

One of the highlights of the event was a banquet featuring slide shows, an original poem written for the event (P. Holmes, Princeton), an original song written for the event (S. Kelly, UI–Urbana-Champaign), and original artwork (D. Bibby, the artist for the TeX and LaTeX books). W. Shadwick (London) and A. Tromba (UC Santa Cruz) were the banquet speakers. Another highlight was a talk, *Shape Optimization for Trailing Edge Noise Reduction*, by Alison Marsden, Jerry’s daughter, a PhD student in mechanical engineering at Stanford.

**Speakers:**
S. Antman (Maryland)  
Analytic Consequences of Incompressibility

R. Brockett (Harvard)  
The Weyl Group as a Symmetry Group for Subriemannian Geodesics

A. Chorin (Berkeley)  
Prediction and Renormalization

M. Dellnitz (Paderborn)  
Set Oriented Numerical Methods in Space Mission Design

J. Duistermaat (Utrecht)  
Second Order Contact of Minimal Surfaces

A. Fischer (UC Santa Cruz)  
Conformal Volume Collapse of 3-manifolds and the Reduced Einstein Flow

P. Garcia Perez (Universidad Complutense de Madrid)  
Poincaré-Cartan Forms in Vakonomic Mechanics: Generalization to Field Theory

M. Golubitsky (Houston)  
Pattern Formation on the Visual Cortex

M. Gotay (Hawaii)  
Obstructions to Quantizing Semisimple Basic Algebras
D. Holm (Los Alamos National Laboratory)
Introduction to Averaged, Regularized, Navier-Stokes Equations for Large Eddy Simulations of Turbulence

P. Holmes (Princeton)
Low Dimensional Models of Turbulent Plane Couette Flow

T. Hughes (Stanford)
Multiscale Methods in Turbulence

J. Isenberg (Oregon)
Gluing Wormholes onto Your Spacetime

K. Kirchgässner (Universität Stuttgart)
Dispersive Dynamics in Euler Systems and Stability of 2D Gravity Solitary Waves

E. Knobloch (Berkeley)
Nearly Inviscid Faraday Waves

N. Kopell (Boston)
A Neuron as a Chain of Oscillators: Transient Dynamics and Integrals

B. Kostant (MIT)
Convexity Theorems and the Order Closure of Nilpotent Orbits

P. Krishnaprasad (Maryland)
Interactions on Lie Groups

M. Levi (Penn State)
New Observations on Parametric Resonance Zones and Geometry of Sympletic Matrices

R. Littlejohn (Berkeley)
Gauge Theory of Small Vibrations in Polyatomic Molecules

M. Lo (Caltech)
The Development of the Interplanetary Superhighway

A. Marsden (Stanford)
Shape Optimization for Trailing Edge Noise Reduction

R. Montgomery (UC Santa Cruz)
Variational Methods for the Newtonian N-body Problem

R. Murray (Caltech)
Nonlinear Control of Lagrangian Systems

A. Newell (Arizona and Warwick)
Global Description of Patterns Far from Onset: Convection in a Large Elliptical Container

M. Ortiz (Caltech)
Asynchronous Variational Integrators

J. Scheurle (Technische Universität München)
On Normal Form Computations

L. Sirovich (Mt Sinai School of Medicine)
On the Dynamics of Cortical Populations

J. Sniatycki (Calgary)
Reduction of Symmetries in Dynamics

A. Weinstein (Berkeley)
The Geometry of Momentum

Workshop on Categorical Structures for Descent and Galois Theory, Hopf Algebras, and Semiabelian Categories
September 23–28, 2002
Organizers: George Janelidze (Georgian Academy of Sciences, University of Aveiro—Portugal), Bodo Pareigis (Munich), Walter Tholen (York)

Classical Galois theory extends in various ways to commutative rings, to schemes in algebraic geometry, and to other algebraic and geometric objects. The “final” and purely categorical version is closely related to Grothendieck’s descent theory, and the Galois group(oid)s involved in its most important examples include varied algebraic structures such as Hopf algebras or internal groupoids in semiabelian and more general categories. Remarkable progress has been made during the seven years since the 1995 Oberwolfach meeting on descent theory. The workshop at the Fields Institute offered an opportunity to discuss a wide spectrum of new ideas and results in four topics, Galois Theory, Descent Theory, Hopf Algebras, and Semiabelian Categories.

The workshop comprised twenty invited and twenty-seven contributed talks and had almost eighty registered participants. F.W. Lawvere, the chairman of the last session of the workshop, expressed on behalf of all participants their sincere thanks to the Fields Institute for hosting a splendid meeting.

Invited Speakers:
Michael Barr (McGill)
A Survey of Homology Theories

Francis Borceux (Université Catholique de Louvain)
Subobjects and Semi-direct Products in Normally Mal’cev Varieties

Dominique Bourn (Université du Littoral)
Intrinsic Centrality and Associated Classifying Properties
Ronnie Brown (Wales Bangor)
*Multiple Groupoids as a Nonabelian Tool for Local-to-Global Problems*

Marta Bunge (McGill)
*Covering Morphisms in Topos Theory*

Stefaan Caenepeel (Vrije Universiteit Brussel)
*Galois Theory for Corings and Cleft Entwining Structures*

Aurelio Carboni (Insubria)
*Fully Embedding (Sober) Topological Spaces in a Category of Coalgebras with a Sequence of Three Universal Constructions*

Peter Freyd (Pennsylvania)
*Algebraic Real Analysis*

Johannes Huebschmann (Lille)
*Lie-Rinehart Algebras, Descent, and Quantization*

André Joyal (UQAM)
*The Theory of Quasi-categories*

F.W. Lawvere (SUNY Buffalo)
*Exponentiation and Nonlinear Homology*

Andy Magid (Oklahoma)
*Galois Theories in Categories: Separable, Differential, and Difference Algebra*

Michael Makkai (McGill)
*Computads, Cellular Sets, and Multitopic Sets*

Robert Paré (Dalhousie)
*The Topos of “Cocommutative Coalgebras”*

Peter Schauenburg (München)
*Monoidal Category Theory Applied to Quasi-Hopf Algebras*

Manuela Sobral (Coimbra)
*Overview of Topological Descent Theory*

Ross Street (Macquarie)
*Formal Representation Theory*

Mitsuhiro Takeuchi (Tsukuba Sakura-Mura)
*Radford-Majid Bosonization via Schauenburg Equivalence*

Miles Tierney (Rutgers)
*Comparing B and W Related Matters*

Enrico Vitale (Université Catholique de Louvain)
*A Little Bit of Homological Algebra for Categorical Groups*

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**General Scientific Activities**

**Weekend Workshops on Arithmetic and Geometry of Higher Dimensional Varieties with Special Emphasis on Calabi-Yau Varieties and Mirror Symmetry**

January 25–26, 2003
March 22–23, 2003

Organizers: Stefan Müller-Stach (McMaster) and Noriko Yui (Queen’s)

The seminars brought together mathematicians with either a complex geometric or arithmetic background sharing a common interest in Calabi-Yau varieties and mirror symmetry. We encouraged the participation of graduate students and postdoctoral fellows.

In January, the speakers were Xi Chen (Edmonton), J. Lewis (Edmonton), D. McKinnon (Waterloo), M. Roth (Queen’s), S. Müller-Stach, and N. Yui. Their talks centred on the geometry and arithmetic of K3 surfaces and Calabi-Yau threefolds. The speakers in March were M. Khalkhali (Western Ontario), M. Roth (Queen’s), R. Sreekantan (Toronto), Y. Goto (Hokkaido), J. Lewis (Alberta) and K. Consani (Toronto). Again the lectures combined arithmetic and geometric methods in various ways. In addition, non-commutative methods were applied in the talks of Khalkhali and Consani.

As interest in both seminars was high, they will be continued in 2003–2004.
Seminars and Colloquia

Regional Colloquium on Applied Mathematics
Organizers: Jim Colliander (Toronto), Nicholas Kevlahan (McMaster), Adrian Nachman (Toronto), Mary Pugh (Toronto)

The invited speakers presented some of the very best current work in partial differential equations, mathematical physics, and medical imaging. Their talks attracted a wide audience of graduate students, postdoctoral fellows, and colleagues from within and without mathematics departments in Southern Ontario. The series was popular not only with the audience but with the speakers themselves, and invaluable for the mathematical discussions it generated inside and outside the seminar room. Charles Fefferman extended his visit to a full week and gave a talk on his work in financial mathematics.

The series was supported by the Fields Institute and by NSERC through the individual grants of the organizers.

Speakers:
Russel Caflisch (UCLA)
*Dynamics of a Step Edge in Thin Film Growth*

Peter Constantin (Chicago)
*Remarks on Rotating Fluids.*

Charles Epstein (Pennsylvania)
*Pulse Synthesis in NMR*

Charles Fefferman (Princeton)
*Formation of Sharp Fronts in 2D Incompressible Fluids*

Sergiu Klainerman (Princeton)
*The Problem of Evolution in General Relativity*

Rafe Mazzeo (Stanford)
*Poincaré-Einstein Metrics on the Large and Small Scale*

Joel Smoller (Michigan)
*Cosmology, Black Holes, and Shock Waves beyond the Hubble Distance*

Combinatorics Seminar
Thursdays, 1–3 p.m., 2002–2003
Held at the Fields Institute

Organizers: Geanina Tudose (Fields Institute) and Michael Zabrocki (York)

The purpose of the weekly combinatorics seminar is to examine topics in algebraic combinatorics that are of interest to the organizers and the audience. For most of this year, the seminar drew upon the expertise of postdoctoral student Alejandra Premat (York), who gave several talks in her area of research—crystal bases of Kac–Moody algebras. Her work influenced the group to adopt this topic as the theme of the seminar. In the fall term, most speakers chose topics from Jin Hong and Seok-Jin Kang, *Introduction to Quantum Groups and Crystal Bases*, as well as from related material.

In January 2003, postdoctoral student Anna Duff (York) joined the seminar. She gave two introductory lectures on super-algebras, after which, under Premat’s leadership, the seminar took up the subject of crystal bases of super-algebras. This is an active area of research, and we hope to soon be able to understand the open questions in the area well enough so that, as a research group, we can begin to answer some of them.

Complexity Theory and Model Theory Seminar
Held at the Fields Institute

Organizers: Bradd Hart (Fields Institute) and Toniann Pitassi (Toronto)

The purpose of the seminars was to explore points of commonality between two areas of logic, complexity theory and model theory. Talks were expository and informal.
Speakers:
Bradd Hart
*Triangle-free Graphs and the Finite Model Property*

Neil Thapen (Toronto)
*Models of Bounded Arithmetic*
*Models of Bounded Arithmetic II*
*Models of Bounded Arithmetic III*
*Models of Bounded Arithmetic IV*
*Models of Bounded Arithmetic V*

**Computational Neuroscience in Upper Canada (CNUC)**
Organizers: Richard Zemel (Computing Science, Toronto), Frances Skinner (Toronto Western Research and UT), and Randy McIntosh (Rotman Research Institute and UT)

Conversations over coffee gave rise to a small group in southern Ontario with an interest in methods and problems in computational neuroscience. The primary motivation was the exchange of information between experimentalists and computational modellers in order to investigate how computational and mathematical approaches have been—or could be—used to address critical issues in neuroscience. The talks are either in tutorial style geared to general scientists or more problem-oriented, where an issue is presented and the floor is then opened for discussion on how to deal with the issue (e.g., we have all this data from brain imaging; how do we characterize the dynamics?). The talks were well attended, and discussion was lively.

Meetings were held on the following topics:
*Different Levels of Modelling*
*Spatial Representations in Motor Control and Navigation*
*The Hippocampus: Memories, Rhythms, Neurogenesis and More!*

**Mathematics outside Mathematics**
Fridays, 2002–2003
Organizers: Jim Colliander (Toronto), David Earn (McMaster), Adrian Nachman (Toronto), and Mary Pugh (Toronto)

This year, a new colloquium series, Mathematics outside Mathematics (affectionately known as “MOM”) was established. Its purpose was to present exciting current scientific and engineering work that involves substantial mathematics but takes place outside mathematics departments. The organizers worked energetically to expose graduate students and postdoctoral fellows to interesting and challenging problems requiring serious mathematics that they would not otherwise encounter. In this spirit, the speakers chosen were top researchers known also for their ability to communicate compellingly across disciplinary lines in both mathematics and their own fields.

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

**Speakers:**
Eugene Fiume (Computer Science, Toronto)
*Signal Theoretic Characterization of Three-dimensional Polygonal Geometry*

Ray Kapral (Chemistry, Toronto)
*Twisting Filaments in Oscillatory Media*

John Sipe (Physics, Toronto)
*Effective Field Theories for Nonlinear Optics in Artificially Structured Materials*

Stuart Whittington (Chemistry, Toronto)
*Randomly Coloured Self-avoiding Walks: A Model of Random Copolymers*

**Working Group on Nonlinear Evolution Equations**
Wednesdays, 2002–2003
Held at the Fields Institute
Organizers: Jim Colliander, Robert Jerrard, and Robert McCann (Toronto)

The Fields working group on nonlinear evolution equations is an informal group of students and researchers in analysis, applied mathematics, and partial differential equations, who convened once a week to discuss mathematical research of common interest. The working group functioned partly as a journal club and partly as a venue for presenting work in progress, especially by young researchers. The theme in 2002–03 centred on nonlinear heat flows and models for fluid mechanics.

The speakers, in addition to the organizers, were Adrian Butscher, Hamed Maroofi, Mary Pugh, Israel Michael Sigal, Dejan Slepcev, and Fridolin Ting (all from the University of Toronto), and Steve Shkoller (UC–Davis).
Quantum Information Seminars

This seminar series has been ongoing since 27 March 2001, and is organized by Daniel Lidar and Aephraim Steinberg (Toronto). It normally meets at the Fields Institute.

The purpose of the seminars is to introduce graduate students, postdoctoral fellows, and faculty, as well as any other interested parties, to the emerging new discipline of Quantum Information Science, including quantum computation, cryptography, teleportation etc. The seminars bring together interested researchers from a variety of backgrounds—mathematics, computer science, physics, chemistry, and engineering.

In addition to support by the Fields Institute, funding was provided through the NSERC, PRO, and DARPA grants of the organizers.

Speakers:

David Bacon (Caltech)
The Cryptographic Universe: Speculations and Real Work on Simulating Quantum Correlations

Somshubhro Bandyopadhyay (Toronto)
An Upper Bound on the Size of the Separable Neighbourhood of a Maximally Mixed State in Any Dimension

Ivan Deutsch (New Mexico); Department of Chemistry
Quantum Information Processing with Ultracold Atomic Qubits

David P. DiVincenzo (T.J. Watson Research Center, IBM); Department of Physics
NonMarkovian Effects in Solid-State Decoherence Prospects for Quantum Computation

Jon Dowling (Jet Propulsion Lab, Pasadena)
Entanglement-Enhanced Quantum Metrology with Linear Optics and Projective Measurements

Jay Gambetta (Griffith University)
The Interpretation of non-Markovian Stochastic Schrodinger Equations: Hidden Variables

Daniel Gottesman (Perimeter Institute)
Imperfect Quantum Error Correction

Xuedong Hu (SUNY–Buffalo)
Silicon Quantum Computation

Misha Ivanov (NRC, Ottawa)
Quantum Information Approach to Quantum Control: Finding an Alphabet for the Language of Molecular Dynamics

Elham Kashefi (Imperial College)
Quantum One-way Permutations

Julia Kempe (Université de Paris-Sud)
Quantum Random Walks

Itamar Pitowsky (Hebrew University of Jerusalem)
Range Theorems for Quantum Probability

Martin Plenio (Imperial College)
Entanglement Manipulation in Continuous Variable Systems

Michael Revzen (Technion, Israel Institute of Technology)
Bell’s Inequality Violation with Local Hidden Variables

Terry Rudolph (Bell Labs)
Quantum Information Is Physical Too

Alexander Sergienko (Boston University); Department of Physics
Quantum Information Processing and Precise Optical Measurement with Entangled Quantum States

Rob Spekkens (Toronto)
In Defense of the View that Quantum States Are States of Incomplete Knowledge

Antony Valentini (Imperial College)
Subquantum Information and Computation

Andrew White (Queensland); Department of Physics
Optical Quantum Computing

Lian-Ao Wu (Toronto)
Identical Particles, Symmetry, and Qubits-Dressed Qubits: A New Method for Eliminating Inherent Gate Errors in Quantum Computation

Zhaoyan Wu (Jilin University, China)
Geometry of Quantum Adiabatical Evolution and Berry’s Connection in Born-Oppenheimer Approximation

Paolo Zanardi (Institute for Scientific Interchange, Torino)
Quantum Information Processing with Semiconductor Macro-atoms
**String Theory Seminars**  
September 2002–April 2003  
Held at the Fields Institute  
Organizer: Erich Poppitz (Toronto)  

The success of the String Theory Seminar series has been remarkable. Leading experts working on issues related to both the mathematical and phenomenological aspects of string theory participated in the seminars and made everyone in attendance aware of the latest developments in the field. Stimulating discussions raised the level of scientific activity within the entire group.  

Funded by the Fields Institute, the Connaught Foundation (Toronto), and the University of Toronto Physics Department  

**Speakers:**  
Sumit Das (Kentucky–Lexington)  
*Issues in Plane Wave Holography*  
Michael Douglas (Rutgers)  
*Chiral Rings and Anomalies in Supersymmetric Gauge Theory*  
Marcus Grisaru (Brandeis and McGill)  
*Perturbative Computation of Glueball Super-potentials*  
Kazuo Hosomichi (Toronto)  
*Liouville Theories with Boundary*  
Lev Kofman (Toronto)  
*Extra Dimensions and Cosmology*  
Albion Lawrence (Brandeis)  
*Local String Models of SUSY Breaking*  
Marcus Marino (Harvard)  
*Matrix Models and the Geometry of Topological Strings*  
Emil Martinec (Chicago)  
*Having the World on a String: Toy Models of Inflation*  
Lee Smolin (Perimeter Institute)  
*Quantum Gravity with a Positive Cosmological Constant*
Off-Site Activities Including Those Sponsored by the National Program Committee

**Fifth Americas Conference on Differential Equations and Nonlinear Dynamics**
July 7–12, 2002
Held at the University of Alberta

Organizers: Co-chairs, M. Li and J. Muldowrey (Alberta), K. Lu (Brigham Young), K. Mischaikow (Georgia Tech.), and J. Wu (York)

The biennial series of Americas Conferences on Differential Equations and Nonlinear Dynamics has served as a major venue for developing and maintaining communication and scholarly exchange among researchers in this field in the Americas. The conference traditionally alternates between North and South America, and in 2002 was held in Canada, at the University of Alberta. The scientific committee included representatives from Brazil, Canada, Chile, Colombia, Mexico, Peru, U.S.A., and Venezuela. The fifth Americas Conference was dedicated to Shui-Nee Chow, one of the founders and a driving force behind the series.

The Americas Conference series has a tradition of encouraging younger mathematicians and graduate students, and has often provided young Latin American mathematicians their first opportunity to present their work before an international audience. This tradition was enhanced in 2002 by an innovative form of scholarly communication—a “Poster Session on the Web”—which enabled those for whom the travel costs were insurmountable to contribute to the conference, to have their work recognized, and to receive feedback.

Over one hundred speakers from fifteen countries attended the fifth Americas Conference, which was deemed an unqualified success by everyone. The sixth conference will be held in Chile in January 2005.

The 2002 conference was sponsored by the National Program Committee (CRM, Fields, PIMS) and the University of Alberta.

**International Conference on Recent Advances in Survey Sampling (ICRASS) in Honour of J.N.K. Rao**
July 10–13, 2002
Held at Carleton University

The Laboratory for Research in Statistics and Probability, Carleton University, University of Ottawa, held a conference in honour of the sixty-fifth birthday of J.N.K. Rao. Rao’s research interests over several decades have been wide-ranging. He has been at the forefront of research in sampling theory and methods, and has made fundamental contributions to the so-called classical theory of sampling, to a variety of aspects of variance estimation, to the analysis of complex survey data, and to small area estimation.

The conference was sponsored by the Laboratory for Research in Statistics and Probability, Carleton University, University of Ottawa, the Survey Research Methods Section of the American Statistical Association, the Fields Institute, and Statistics Canada.

**AARMS International Workshop on Nonlinear Dynamical Systems with Applications**
July 15–18, 2002
Held at Memorial University

Organizers: Xiaoqiang Zhao and Hermann Brunner (Memorial University)

The workshop was a follow-up event to the Fifth Americas Conference on Differential Equations and Nonlinear Dynamics (University of Alberta, July 7–12, 2002). Its purpose was to provide an informal opportunity for researchers and graduate students in the fields of nonlinear differential equations and dynamical systems, and their applications, to communicate new research results, ideas, and open problems; to discuss future research directions; and to initiate research collaborations in a sympathetic small setting. The workshop topics included the asymptotic behaviour in finite and infinite dimensional dynamical systems, special solutions in partial differential equations (steady states, waves, etc), Hamiltonian systems and Morse theory, bifurcations and chaos, evolution equations and population biology, and numerical methods in nonlinear (functional) differential equations. There were twenty-five researchers, including six graduate students, in attendance.

Jianhong Wu (York University), AARMS Distinguished Lecturer, spoke on Nonlocal Interaction through Spatial Diffusion and Temporal Delay: Dynamics and Biological Applications.

The invited fifty-minute lectures were given by T. Faria (University of Lisbon), A. Foster (Memorial University), Yuxia Guo (Tsinghua University), M. Gyllenberg (University of Turku), J. Haddock (University of Memphis), S. Hastings etc.
(University of Pittsburgh), Jingtang Ma (Memorial University), A. Mingarelli (Carleton University), J. Muldowney (University of Alberta), G. Sell (University of Minnesota), H. Thieme (Arizona State University), Dashun Xu (Memorial University), Jianhong Wu (York University), Yingfei Yi (Georgia Institute of Technology), and Hermann Brunner.

These wide-ranging talks were complemented by a successful and well-attended public lecture by George Sell on Predictions of the El Nino Event: A Mathematical Perspective.

The workshop was sponsored by the National Program Committee (CRM, Fields, PIMS).

AARMS Summer School
July 22–August 16, 2002
Held at Memorial University

The Atlantic Association for Research in the Mathematical Sciences (AARMS) hosted a summer school in July 2002, the first of its kind in Canada. Twenty-two students (for the most part graduate students) from China, Germany, Poland, Turkey, Alaska, Alberta, British Columbia, Newfoundland, Nova Scotia, Ontario, and Quebec registered for two intensive courses from a selection of four offered. Instructors and their courses, each of which involved seven hours a week of lectures and tutorials, were:

Cesar Polcino Milies (Sao Paulo), Algebra
Jason Brown (Dalhousie), Combinatorics
Sue Ann Campbell (Waterloo) and Penny Davies (Strathclyde), Differential Equations
Kathryn Hare (Waterloo), Fractal Geometry

The goals of the AARMS School, which is modelled after one in Perugia, Italy, now in its thirty-second year, are to provide young researchers with basic training in mathematics and its applications, to encourage strong undergraduates to continue their studies at the graduate level, and to raise the profile of mathematics and of mathematical research in Atlantic Canada. Students from outside Atlantic Canada are responsible for their transportation to St. John’s, but upon arrival there, all expenses are covered, including texts and course notes.

The summer school was sponsored by the National Program Committee (CRM, Fields, PIMS), Dalhousie University, Memorial University, and the University of New Brunswick.

Fourteenth Canadian Conference on Computational Geometry
August 12–14, 2002
Held at the University of Lethbridge
Organizer: Stephen Wismath

The fourteenth Canadian Conference on Computational Geometry took place in August 2002 at the University of Lethbridge. The sixty-five participants from eleven countries heard thirty-nine papers, of which the top seven or eight will be published in a special issue of the journal Computational Geometry: Theory and Applications, ed. S. Wismath and H. Everett. The three invited speakers were:

L. Devroye (McGill)
Paul Erdős Memorial Lecture

U. Kortenkamp (Freie Universität Berlin and Cinderella Corp.)
Cinderella: Computation, Complexity, Geometry

S. Wagon (Macalaster College)
A Machine Resolution of a Four-Colour Hoax

The conference was sponsored by the National Program Committee (CRM, Fields, PIMS).

International Workshop on Polynomial Identities in Algebras
August 29–September 3, 2002
Held at Memorial University of Newfoundland
Organizers: Y. Bahturin (Memorial University), A. Giambruno (University of Palermo, Italy), A. Regev (Weizmann Institute of Science, Israel), and M. Zaicev (Moscow State University)

The workshop on Polynomial Identities in Algebras (Combinatorial Methods) was the fifth in a series that began in 1992. In the past five years, the area has experienced intensive growth, and a number of problems which had remained open for several decades have been solved.

The workshop attracted twenty-eight participants—spanning mathematical generations—from seven countries. V. Latyshev (Moscow University), who started his work more than forty years ago, delivered survey lectures on recent achievements of younger Russian algebraists on Specht’s problem in positive characteristic (a central problem in this area since the 1950s). A. Kemer (Ulyanovsk University), who solved Specht’s problem in the most
important case of zero characteristic, gave a lecture on his achievements in solving Procesi’s problem. A. Regev, whose work and that of S. Amitsur formed the basis for much of the progress in PI-algebras over several decades, spoke on $A_{p'}$-codimension and Co-characters. A. Giambruno gave lectures on his joint work with M. Zaicev, the results of which have completely changed the face of the theory in the past five years. Among the lecturers was E. Formanek (Penn State), whose work on central polynomials was a sensation in the 1970s and remains one of the basic tools in all research on PI-algebras.

On one day of the Labour Day weekend, participants visited the Seabird Sanctuary on the Cape of St. Mary.

The workshop was sponsored by the National Program Committee (CRM, Fields, PIMS); by the Atlantic Association for Research in Mathematical Sciences (AARMS); by the President and Dean of Science of Memorial University; and by its Department of Mathematics.

**Ontario Combinatorics Workshop**

*May 1–2, 2003*

**Discrete Mathematics Day**

*May 3, 2003*

Held at University of Ottawa

Organizers: Sylvia Boyd (Ottawa), Jason Gao (Carleton), Lucia Maura (Ottawa), Daniel Panario (Carleton), Irwin Pressman (Ottawa), Mateja Sajna (Ottawa), Brett Stevens (Carleton)

The Ontario Combinatorics Workshop (OCW) encompasses the full range of subjects in combinatorics, discrete mathematics, and related areas, and it especially encourages presentations by graduate students and young researchers. There were seventy-one registered participants and twenty-seven presentations, including twenty-three by graduate and undergraduate students.

Graduate student Marni Mishna (LaCIM, UQAM) won the Peter Rodney book prize for the best student presentation for her talk on *New Algorithms for Symmetric Functions Useful in Combinatorial Enumeration*.

**Plenary speakers:**

Nick Wormald (Waterloo)  
*Two Choices Are Better Than One, But by How Much?*

Brian Alspach (Regina)  
*Poker and Mathematics*

Sylvia Boyd (Ottawa)  
*Methods for Hard Combinatorial Optimization Problems: A Guided Tour*

Ram Murty (Queen’s)  
*Ramanujan Graphs*

The Discrete Mathematics Day is an event held annually in Ottawa, alternating between the University of Ottawa and Carleton University. This year, it was held at the University of Ottawa on May 3. Organizers hoped that coordinating the Discrete Mathematics Day with the Ontario Combinatorics Workshop would attract a larger audience—especially graduate students—to future DMDs. There were four invited talks, covering the areas of combinatorial optimization, combinatorial number theory, combinatorial generation and search, and graph theory.

**Invited Speakers:**

Bill Cunningham (Waterloo)  
*Even Factors in Digraphs*

Endre Szemerédi (Rutgers)  
*Long Arithmetic Progressions in Sum-set Sums*

Clement Lam (Concordia)  
*Block Design Existence—When It Rains, It Pours*

Brian Alspach (Regina)  
*Searching and Sweeping Graphs*

Funding was provided for the two interlocking events by the Fields Institute and the University of Ottawa.

**Southern Ontario Numerical Analysis Day**

*May 2, 2003*

Held at McMaster University

Organizers: Ned Nedialkov, Jiming Peng, Tamás Terlaky (McMaster University)

The twenty-first Southern Ontario Numerical Analysis Day (SONAD) was hosted by the Advanced Optimization Laboratory, Department of Computing and Software, McMaster University. In addition to two invited talks, there were nine contributed talks and a poster session. The topics included new methods for solving PDEs, optimization and applications of numerical methods to electromagnetics, finance, wave propagation, and fluid-structure interaction.

The conference was sponsored by the McMaster Faculty of Engineering, the Fields Institute, and MITACS.
Invited Speakers:
Tony Chan (Mathematics, UCLA)
A Fast Algorithm for Variational Level Set Image Segmentation

Michael Overton (Courant Institute of Mathematical Sciences, NYU)
Measuring and Optimizing Stability of Matrices

Conference in Number Theory in Honour of H.C. Williams
May 24–30, 2003
Held at the Banff Centre
Organizers: Michael Jacobson (Calgary), Renate Scheidler (Calgary), Jon Sorenson (Butler), Andreas Stein (UIUC), Gary Walsh (Ottawa)

Over one hundred participants attended a conference in Number Theory at the Banff Centre in honour of the sixtieth birthday of Hugh Williams of the University of Calgary. Williams’s work includes research in areas of number theory pertaining to computational problems, and in public-key cryptography, which connects number theory to information security. He is the founder of the Centre for Information Security and Cryptography (CISAC) in the Department of Mathematics at Calgary.

There were fifty-six lectures, including five plenary lectures and one special lecture by Manindra Agrawal (Indian Institute of Technology, Kanpur), who spoke on his recent astounding proof that the problem of determining primality can be solved in polynomial time. Proceedings will be published in the Fields Monograph Series.

Funding for the conference was provided by the Fields Institute, the National Security Agency, the Number Theory Foundation, CISAC, and RSA Security Inc., and the University of Calgary.

Special Lecture:
Manindra Agrawal (IIT, Kanpur)
A Polynomial-time Algorithm for Primality Testing

Plenary Speakers:
Peter Borwein (SFU)
Three Highly Computational Problems in Number Theory

Johannes Buchmann (Darmstadt)
Cryptography in Quadratic Fields

Andrew Granville (Montreal)
On the Research Contributions of H.C. Williams

Carl Pomerance (Bell Labs)
Primality Testing with Gaussian Periods

Alf Van Der Poorten (Macquarie)
Periodic Continued Fractions and Elliptic Curves

Fields Summer School on Logic and Foundations of Computation
June 2–20, 2003
Held at the University of Ottawa
Organizers: Rick Blute, Philip Scott, and Peter Selinger (University of Ottawa)

Forty-three graduate students and an assortment of researchers and visitors attended the Fields summer school on Logic and the Foundations of Computation, held at the University of Ottawa June 2–20. The first two weeks consisted of four mini-courses, followed in week three by four specialized workshops.

Week one began with three courses: Phil Scott (Ottawa) spoke on Categorical Logic; Peter Selinger (Ottawa) on Classical Logic; and Rick Blute (Ottawa) on Linear Logic. Their courses were augmented by lectures from visiting scholars: T. Ehrhard (Luminy) presented two lectures on Finiteness Spaces and Differential Lambda Calculus; and Robert Seely (McGill) and Robin Cockett (Calgary) gave an overview of proof nets, linear categories, and coherence theorems.

The second week was highlighted by two mini-courses given by invited scholars: Samson Abramsky (Oxford) and Guy McCusker (Sussex) gave a course in Game Semantics for Programming Languages, while Glynn Winskel (Cambridge) spoke on Concurrency Theory. There was also a special lecture by visiting researcher Y.-Y. Girard (Luminy).

Throughout all the lectures, attendees were presented with open problems. In addition, during the first two weeks, there were short graduate student presentations lasting ten to fifteen minutes each in which fifteen students spoke on their current research.

The final week comprised four workshops. The first, organized by Selinger, on Quantum Programming, highlighted current research on the mathematical foundations and design of programming languages for quantum computing. Abramsky organized a workshop on Game Semantics, which brought together the top researchers in this very active topic. These were followed
by a workshop on Computational Linguistics organized by Jim Lambek (McGill), in which many of the world’s experts surveyed applications of recent work on mathematical linguistics (type grammars) to natural language. The final workshop, organized by Winskel, was on Concurrency and Mobility. It brought together experts on concurrency and mobility to discuss the mathematical foundations as well as applications of current research—applications which ranged from calculi for name-passing and concurrency to security and computational molecular biology.

As the Fields summer school and workshops were sandwiched between the FMCS 2003 meeting (an annual informal meeting of mathematicians and computer scientists interested in applications of category theory and semantics in computer science) and the IEEE Eighteenth Annual Symposium on Logic in Computer Science (LICS 2003), many people stayed on for multiple events and actively participated in them. Taken altogether, June in Ottawa was a rich month for anyone interested in the foundations of computing.

Finally, the scientific activities of the summer school were leavened by a visit to the Canadian Museum of Civilization and a guided tour of the Canadian Parliament. Afternoons found many students organizing impromptu sports events.

Winter 2002 Meeting of the
Canadian Mathematical Society
December 8–10, 2002
Held at the Ottawa Marriott Hotel

Organizers: Meeting Director, D. Daigle (Ottawa), M. Bouchard (CMS), W. Burgess (Ottawa), A. Dabrowski (Ottawa), A. Sebbar (Ottawa), G. Wright (CMS)

Plenary Speakers:
J. Arthur (Toronto)
Universal Groups in the Theory of Automorphic Forms

R. Carmona (Princeton)
Mathematical Challenges of the Energy Markets

V. Guillemin (MIT)
Cutting and Glueing in Symplectic Geometry

M. Zworski (Berkeley)
Quantum Resonances in Chaotic Scattering

Coxeter–James Lecture:
L. Jeffrey (Toronto)
Symplectic Quotients and Their Cohomology

Public Lecture:
R. Zuccherato (Entrust, Inc.)
Passwords: Are They the Weakest Link?

CMS Doctoral Prize Lecture:
D. Kerr (Tokyo and University of Rome)
C*-Dynamics and Entropy

In addition there were 217 talks presented in 12 organized symposia and a session of contributed papers. All told, there were 362 participants.

The meeting was sponsored by the Canadian Mathematical Society, the National Program Committee (CRM, Fields, PIMS), the University of Ottawa, the Faculty of Science of the University of Ottawa, and the Department of Mathematics and Statistics of the University of Ottawa.

Summer 2003 Meeting of the
Canadian Mathematical Society
June 14–16, 2003
Held at the University of Alberta

Organizers: Meeting Director, YanPing Lin (Alberta), T. Choulli (Alberta), Terry Gannon (Alberta), Bin Han (Alberta), Thomas Hillen (Alberta), B. Huang (Alberta), RongQing Jia (Alberta), Y. Lin (Alberta), Vazz Linek (Winnipeg), S. Liu (Alberta), Ted Lewis (Alberta), Peter Minev (Alberta), Maung Min-Oo (McMaster), George Peschke (Alberta), Michael A. Radin (Rochester Inst. of Tech.), Erik Talvila (Alberta), John van Rees (Manitoba), Laura Scull (UBC), Tony Ware (Calgary), Eric Woolgar (Alberta), Mark Walton (Lethbridge), XiaoQiang Zhao (Memorial), Peter Zwengrowski (Calgary), Graham Wright (CMS ex-officio), Monique Bouchard (CMS ex-officio).

There were 348 registered participants. Special sessions were held on the following topics: Algebraic and Geometric Topology, Approximation Theory and Applied Harmonic Analysis, Computational and Analytical Techniques in Modern Applications, Conformal Field Theory, Design Theory and Coding Theory, Discrete Mathematics, Dynamical Systems, Industrial Mathematics, Infinite Dimensional Dynamical Systems, Mathematical and Computational Finance, New and Successful Courses and Programmes in Mathematics, Real Analysis, Physics and Geometry.

Public Lecture:
Robert Moody (Alberta)
Tilings: An Evening Excursion to the Zoo
Plenary Speakers:
Ingrid Daubechies (Princeton)
*An Iterative Algorithm for Linear Inverse Problems with a Sparsity Constraint*

Roland Glowinski (Houston)
*Operator Splitting Methods for Initial Value Problems: Application to the Direct Numerical Simulation of Particulate Flow and to Computational Differential Geometry*

Gerhard Huisken (Tübingen/Albert Einstein Institute)
*Surgery for Geometric Evolution Equations*

James Lepowsky (Rutgers)
*An Introduction to Vertex Operator Algebra Theory and Some of Its Problems*

Dennis Shasha (Courant Institute).
*Upstart Puzzles*

Jeffery-Williams Lecture:
Ram Murty (Queen’s)
*Ramanujan Graphs and Zeta Functions*

Krieger-Nelson Lecture:
Leah Keshet (UBC).
*Mathematical Biology of Cellular and Biomedical Problems*

Plenary Speakers: Ingrid Daubechies (Princeton)
*An Iterative Algorithm for Linear Inverse Problems with a Sparsity Constraint*

Roland Glowinski (Houston)
*Operator Splitting Methods for Initial Value Problems: Application to the Direct Numerical Simulation of Particulate Flow and to Computational Differential Geometry*

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Krieger-Nelson Lecture:
Leah Keshet (UBC).
*Mathematical Biology of Cellular and Biomedical Problems*

The meeting was sponsored by the CMS, the National Program Committee (CRM, Fields, PIMS), the University of Alberta Department of Mathematical and Statistical Sciences, Conference Fund, Faculty of Science, Theoretical Physics Institute, and Applied Mathematics Institute, the University of British Columbia Faculty of Science and Mathematics Department, the University of Lethbridge, the Perimeter Institute for Theoretical Physics, the Canadian Institute for Theoretical Astrophysics, and Nelson, A Thomson Company.

Sponsors of the meeting were the Centre de recherches mathématiques, PIMS, the Fields Institute, Dalhousie University, and the Department of Mathematics and Statistics of Dalhousie.

Presidential Invited Address:
Robert Gentleman (Harvard School of Public Health)

Gold Medal Address:
Muni Srivastava (Toronto)

Special Invited Addresses:
Pierre Lavallée (Statistics Canada)
Douglas C. Montgomery (Arizona State)
J.N.K. Rao (Carleton)
Edward F. Vonesh (Baxter Healthcare Corporation)

Joint Meeting of CAIMS/SCMAI and SIAM
June 16–20, 2003
Held at Queen Elizabeth Hotel, Montreal

Organizers: Canadian Chair, Jacques Bélair (Université de Montréal); U.S. Chair, Ilse Ipsen (North Carolina State University)

The first joint meeting of the Canadian Applied and Industrial Mathematics Society (CAIMS)/Société Canadienne de Mathématiques Appliquées et Industrielles (SCMAI) with the Society for Industrial and Applied Mathematics (SIAM) was held in June in Montreal. The joint meeting was held in conjunction with the twenty-fourth annual general meeting of the CAIMS/SCMAI.

Among the sponsors were the CRM, PIMS, and Fields.

Invited Plenary Speakers:
Michel Delfour (Montréal)
Raymond Laflamme (Perimeter Institute)
Eli Lablonovitch (UCLA)

Invited Topical Speakers:
Walter Craig (McMaster)
Ary L. Goldberger (Beth Israel Deaconess Medical Center)
Larry D. Greles (Systems Biology Consulting Group, Canada)
James L. Kaiser (Duke)
Suzanne Lenhart (Tennessee)
Mark Lewis (Alberta)
William A. Massey (Princeton)
James C. McWilliams (UCLA)
Nico M. Temme (CWI, Netherlands)
John von Neumann Lecturer:
Heinz-Otto Kreiss (UCLA)

Sponsors of the meeting were the Centre de recherches mathématiques, PIMS, the Fields Institute, Dalhousie University, and the Department of Mathematics and Statistics of Dalhousie.
Quantitative Finance Seminars
September 2002–April 2003
Held at the Fields Institute

Organizers: Phelim Boyle (Waterloo); Michel Crouhy (CIBC); Donald A. Dawson (McGill); Ron Dembo (Algorithmics), Bradd Hart (Fields); Alexander Levin (TD Financial Group); Thomas McCurdy (Toronto); Moshe Milevsky (IFID Centre and the Schulich School of Business, York); Dan Rosen (Algorithmics); Tom Salisbury (York); Luis Seco (Sigma); Stuart Turnbull (CIBC)

The Quantitative Finance Seminars consist of monthly talks on current research in quantitative finance that are of interest to people working on the border of industry and academia. In 2002–2003, each seminar was organized around a single theme, and generally featured two talks with a reception during the intermission. Overflow audiences spoke to the continued relevance of mathematics to the financial sector.

Quantitative Finance Seminar talks were sponsored by MITACS, IFID, the Professional Risk Management International Association, and Sigma Analysis and Management.

Speakers:
John Hull (Rotman School of Management)
The Credit Derivatives Market

Alan White (Rotman School of Management)
Can Credit Default Swap Spreads Be Used to Predict Downgrades?

Dan Rosen (Algorithmics)
Understanding Stochastic Exposures and LGDs in Portfolio Credit Risk

Greg M. Upton (Moody’s Risk Management Services)
Measures of Debt Security Loss Given Default

Philippe Artzner (Université de Strasbourg)
Multiperiod Risk Measurement: Where Are We?

John Manistre (Mercer Human Resources Consulting)
Measures of Covariance in the Tail of a Loss Distribution

Don Lindsey (University of Toronto Asset Management Corporation)
Investment Darwinism: Hedge Funds and the Evolution of Investment Management

Myron Scholes (Stanford Graduate School of Business)
Liquidity, Chaos, and Hedge Funds

David Heath (Carnegie Melon)
The Consistency of Two Markets

Phelim Boyle (Waterloo)
Embedded Options in Insurance Contracts: Guaranteed Annuity Options
First International Workshop on Ad-hoc Networks and Wireless (“ADHOC-NOW”)  
September 20–21, 2002  
Held at the Fields Institute  
Organizers: Michel Barbeau (Carleton), Evangelos Kranakis (Carleton)

A workshop on the emerging field of ad-hoc networks brought together mathematicians, computer scientists, and engineers for two days in September 2002. The workshop encompassed architectures, access control and discovery, multicasting protocols, performance, quality-of-service, routing protocols, scalability, secure services, and self-configuration.

Ad-hoc networks consist of multiple, interconnected devices that also act as routers. The devices may be moving, thus forming a network topology that is constantly changing. Ad-hoc networks are an “infrastructureless” technology usually associated with military and emergency applications. Interest in the field has recently grown significantly because of its boundless commercial possibilities.

This workshop was generously supported by Mathematics of Information Technology and Complex Systems (MITACS).

**Invited speakers:**
- A. Ephremides (Maryland)  
  *Energy Awareness in Wireless Networking*
- R. Liscano (Mitel Networks)  
  *Ad-hoc Communications in the Enterprise*
- L. Narayanan (Concordia)  
  *Dynamic Construction of Bluetooth Scatternets*
- C. Perkins (NOKIA Corporation)  
  *Ad-hoc, MANET, AODV, and ng*

**In addition eighteen research papers were presented:**
- D. Belis (Sheffield)  
  *Estimation in Variance of Delay for Types of Multi-access Control Systems*
- G. Chakrabarti (Michigan State)  
  *A Modified Approach to Dynamic Source Routing in Mobile Ad-hoc Networks*  
  *Adaptive Topology Discovery in Hybrid Wireless Networks*
- Y. Deng (National Taiwan University)  
  *An Efficient Adaptive Medium Access Control Protocol for Reliable Broadcast for Ad-hoc Networks*
- D. Evans (Cardiff)  
  *Optimization in the Design of Mobile Ad-hoc Networks with Steerable Directional Antennae*
- A. Ghavam (Ottawa)  
  *Enabling Secure Ad-hoc Communications in the Enterprise*
- Y. Hwang (Syracuse)  
  *TCP Performance Enhancement with an Adaptive Routing Algorithm in Wireless Ad-hoc Networks*
- T. Kunz (Carleton)  
  *An Architectural Framework for Ad-hoc Wireless Networks QoS Interaction with Access Domains; Energy Consumption in Ad-hoc Routing Protocols: Comparing DSR, AODV, and TORA*
- J. Lipman (Wollongong)  
  *Efficient Scalable Information Dissemination in Mobile Ad-hoc Networks*
- I. Nikolaidis (Alberta)  
  *Connected Disc Covering and Applications to Mobile Gateway Placement in Ad-hoc Networks*

**Commercial/Industrial Mathematics**
C. Schwingenschlogl (Munich University of Technology)
Ad-hoc Security Support Using DVB-T

I. Stoimenovic (Ottawa)
Partial Delaunay Triangulation and Degree
Limited Localized Bluetooth

Information Conference on Alternative Investing
October 17, 2002
Held at the Fields Institute
Organizers: Luis Seco (Sigma) and David Rudd (Sigma)
The Fields Institute and Sigma Analysis and Management jointly hosted a one-day presentation by global hedge fund managers. Such managers use a variety of financial engineering techniques including derivatives and quantitative arbitrage with the objective of generating sustainable predictable investment returns. Speakers described their strategies to achieve returns independent of traditional markets. The following management firms were represented: Canadian Hedge Watch (information source on Canadian hedge funds); IIG (U.S. commodity factoring and specialized lending firm); Advent Capital (U.S. convertible arbitrage investor); Beacon Hill Asset Management (U.S. trader of mortgage-backed securities); Rotella Capital Management (U.S. commodity trading advisor); J.C. Clark (Canadian long/short equity manager); Sigma (Canadian hedge fund and research investment firm).

Workshop on Industry, Business, Mathematics, and Computer Algebra
October 25, 2002
Held at the Fields Institute
Organizer: D. Jeffrey (Ontario Research Centre for Computer Algebra)
In the worlds of industrial and financial mathematics, there is a common perception that the computer tools used are mainly numerically based. Symbolic computation (“computer algebra”) packages such as Maple are thought to be the tools only of research mathematicians and educators. A one-day workshop on the industrial applications of computer algebra showed that computer algebra packages have penetrated the world of industrial mathematics to a greater extent than generally realized. The seven talks required close attention from the audience in order to grasp the essentials of a wide variety of business and industrial problems and the corresponding mathematical challenges.
Generously supported by Waterloo Maple, Inc.

Speakers:
Gregory Frank (Bank of Montreal)
From the Lecture Hall to the Trading Floor: Some Examples of Computer Algebra in Computational Finance
Raya Khanin (Glasgow)
Case Studies in Industrial Applications from Britain
Tom Lee (Waterloo Maple)
Practical Software Techniques for Industrial Mathematics: A Survey and Demonstration
Douglas Moseley (Radiation Therapy Physics, Princess Margaret Hospital)
Geometric Calibration of a Cone-Beam CT System for Image-Guided Radiotherapy
H. Rasmussen (Simulation Western)
Modelling an Airbag Sensor
Daniel Stubbs (Nanodesign)
Examples of Computational Chemistry
Clifton Williamson (Seagate VLSI)
Computer Algebra and Coding Theory: Two Applications
Conference on Monte Carlo Methods
November 9, 2002
Held at the University of Western Ontario

There were seven speakers at this one-day workshop on Monte Carlo Methods in Quantitative Finance, including the keynote speaker, Phelim Boyle (Waterloo), considered to be the father of Monte Carlo methods in pricing and hedging financial options. All talks were accessible to a general mathematically and financially literate audience.

Sponsored jointly by SHARCNET and the Fields Institute

Speakers:
Phelim Boyle
*Applications of the Monte Carlo Method in Finance*

David Jamieson Bolder (Financial Markets Department, Bank of Canada)
*A Debt Strategy Simulation Model*

George J. Jiang (Arizona)
*Hedging Derivatives Risks*

Alexander Kreinin (Algorithmics)
*Integrated Market and Credit Risk Modelling*

Duncan Murdoch (Western)
*Introduction to Perfect Sampling*

Marcel Rindisbacher (Toronto)
*Malliavin Calculus for Monte Carlo Methods in Finance*

Ken Seng Tan (Waterloo)
*A General Dimension Reduction Technique for Derivative Pricing*

Second Annual Personal Risk Management Conference
November 21, 2002
Held at the Fields Institute

Organizer: Moshe Milevsky (IFID Centre and Schulich School of Business, York)

The Individual Finance and Insurance Decision Centre held its second annual Personal Risk Management Conference in November 2002. The conference focused on personal finance and insurance, as well as on the application of quantitative and rigorous financial techniques to the decisions individuals face in their daily lives. Opening remarks were made by B. Hart (Fields Institute), M. Milevsky, and K. Adams (the Investor e.ducation Fund). Six speakers addressed a diverse audience on various facets of personal finance—after-tax aspects of mutual funds, tax-deferred accounts, the psychology of finance, fund ratings, borrowing at fixed or floating rates, and consumer access to real mortgages whose payments are linked to the Consumer Price Index (CPI).

The conference was generously sponsored by the Investor e.ducation Fund.

J. Poterba (MIT)
*After-Tax Benchmarks for Individual Investors*

C. Spatt (Carnegie Mellon)
*Optimal Asset-Location and Allocation with Taxable and Tax-Deferred Investing*

T. Odean (Berkeley)
*Recent Developments in Behavioural Finance*

M. Stutzer (Colorado)
*The Ratings Game: What is the Risk in Risk-Adjusted Mutual Fund Returns?*

S.-A. Persson (Norwegian School of Economics)
*Debt Allocation: To Fix or To Float?*

J. Cocco (London School of Business)
*Optimal Risk Management and Optimal Mortgage Choice*
FOSTERING START-UP FIRMS

Sigma Financial Analysis and Management
Sigma is a financial analysis and management firm housed within and assisted by the Fields Institute. It was founded by David Rudd and Luis Seco of the University of Toronto. For the first eighteen months, Sigma analysed the performance of hedge funds, trading advisors, and other investment managers who try to provide superior investment returns. The object of the research was to construct portfolios of investments which can insulate investors from risk to the economy and provide superior, sustainable returns. “Investors and institutions such as pension funds are looking for alternatives to exposure to the economy and will want positive returns with investment profiles not dependent on economic growth. Sigma’s detailed research permits us to deliver that product,” comments David Rudd.

Sigma has two basic business themes: 1) providing investment consulting services to large financial institutions in Canada, the U.S., and South America; 2) investing with over eighty global hedge funds on behalf of large investors.

Sigma has seven full-time staff including four senior math researchers and is now registered as an investment counsellor.

The Individual Finance and Insurance Decisions (IFID) Centre @ the Fields Institute
The Individual Finance and Insurance Decisions Centre (IFID) is a non-profit research centre that is currently housed at the Fields Institute and closely associated with the Schulich School of Business at York University in Toronto.

The broad objectives of the IFID Centre are to conduct and disseminate applied research in the field of financial risk management for individuals. This mandate covers the areas of finance, insurance, economics, actuarial science, taxation, operations research, law, psychology, sociology and marketing, insofar as they apply to individual consumers and their financial decisions.

IFID has two primary and ongoing activities. The first is to link and support a wide network of academic researchers interested in the topic of personal finance and insurance. The second is to engage in quantitatively-based contract work for industry and government. The IFID Centre is supported by a variety of sponsors that provide funding for targeted research projects, graduate and post-doctoral fellowships, and an annual conference devoted to personal risk management.

The IFID Centre’s organizational structure consists of an Executive Director, a governing board of directors, in-house support staff, and off-site research associates from industry and academia. The current executive director of The IFID center is Moshe A. Milevsky, a Finance Professor at the Schulich School of Business, York University.

For more information, please visit www.ifid.ca.
Mathematics Education

Mathematics Education Forum
Organizers: Stewart Craven (Toronto District School Board), Eric Muller, Co-chair (Brock), and Tom Steinke (President, OMCA)

Summer 2002 was an active period for a number of Forum members who organized and ran four-day FATHOM workshops for one hundred and sixty teachers in Toronto, Ottawa, London, Kingston, and Sudbury. FATHOM is an educational statistics software that promotes exploration in data analysis. Licensed for all schools in Ontario, it is one of the major tools for the Grade 12 course — Mathematics of Data Management (MDM4U)— a course new to most secondary teachers. The Forum provided development support through its summer workshops and through a task force initiated two years ago, chaired by Shirley Dalrymple and Sandy Dilena.

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

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

The Task Force on On-Line Mathematics Learning continued its activity, February 27–March 1, 2003, and is reported on separately.

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

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

The dedication of the many mathematics educators who give a Saturday every month to meet and work to improve mathematics education is remarkable. In bringing together mathematics educators from primary, secondary, and postsecondary institutions, and individuals in the publishing industry, the Fields Mathematics Education Forum provides a service to mathematics students at all levels of the subject.
Mathematics Online
Organizers: George Gadanidis (Western), Lynda Graham (OCMA), William Higginson (Queen’s), Douglas McDougall (OISE), Geoffrey Roulet (Queen’s)

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

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

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

Most of the rest of the meeting was devoted to the discussion of three questions. The first was “what is happening online that we like?” In preparation for this session, participants had been invited during the previous two weeks to explore a number of different examples of online materials ranging in scale and type, including several developed by members of the group. The second question was “what do we want to do online in terms of mathematics education?” The final question, discussed in small groups of individuals with common interests, asked “how would we design an exemplary online activity?” A sharing of some
of the preliminary efforts of the different groups to answer these questions and a general discussion of the major points of agreement that had emerged over the two days brought this stimulating and enjoyable gathering to a close at lunch-time on Saturday.

Considerable material related to the meeting, in particular the first White Paper and the Papert–Kay talks, may be seen at www.fields.utoronto.ca/programs/mathed/meforum/online/.

**Mathematics as Story Symposium**
June 13–15, 2003
Held at the University of Western Ontario
Organizers: George Gadanidis (Education, UWO), Cornelia Hoogland (Education, UWO), and Kamran Sedic (Faculty of Science and Faculty of Information and Media Studies, UWO)

A symposium on mathematics seen through the lenses of art and technology, “Mathematics as Story,” was held in June 2003 at the University of Western Ontario. Human cognition is story-based, that is, people learn by living and accommodating new stories, and by defining themselves through the stories they imagine. The symposium explored how such perspectives might be employed in teaching and learning mathematics.

The organizers purposely sought to cross discipline boundaries in their choice of keynote speakers. Their talks, open to the public, were followed by discussants’ comments and then by questions from the audience.

Keynote speakers: Ellen Dissanayake (visiting scholar, Walter Chapin Simpson Center for the Humanities, University of Washington), author of *Homo Aestheticus: Where Art Comes from and Why?* (1992), discussant, Bill Higginson (Queen’s); Rena Upitis (Queen’s), author of *Creative Mathematics: Exploring Children’s Understanding* (1997), discussant Eric Muller (Brock); and Brian Boyd (Department of English, University of Auckland), author of *Vladimir Nabokov: The Russian Years* and *Vladimir Nabokov: The American Years* (1990, 1991), discussant David Pimm (Alberta).

The Mathematics as Story Symposium was sponsored jointly by the Fields Institute and the Faculty of Education, University of Western Ontario.

**Mathematics Camps Program 2002**
In only a few years, the Mathematics Camps Program has grown to include at least one camp in every province. In 2002, in addition to two International Mathematics Olympiad (IMO) training camps and one national camp, thirteen regional camps took place across Canada.

The winter IMO training camp was at York University in January 2002, and the summer IMO camp at Memorial University of Newfoundland in July 2002. The winter camp was attended by fifteen students selected from across Canada. The summer camp provided concentrated training for the six students chosen to represent Canada at the forty-third IMO in Glasgow. In addition, six local students attended some of the sessions during the first week. The Canadian team did remarkably well at the IMO—they tied for twelfth out of eighty-four participating countries. They won one gold medal, three silver medals, one bronze medal, and an honourable mention.

The national camp is designed for students with the potential to make the Canadian IMO team two or three years thereafter. In 2002, twenty-five students were invited to the camp, which was held at the University of Western Ontario. The national camp program began in 1998, and part of the recent success of the Canadian IMO team may be due to early identification of potential members and their subsequent encouragement and training.

Summer Math Camp, Ottawa
The thirteen regional camps are designed to provide students with mathematics enrichment in a rewarding environment that is fun for them. There are usually about twenty-five students from grades 9 to 11 at each camp. The camp format depends upon the preference of the local host university: some are day camps lasting two to five days; some are weekend residential camps; and some are week-long residential camps. In 2002, regional math camps were organized at Sir Wilfred Grenfell College, the University of New Brunswick (Fredericton), Dalhousie University, Collège Jean de Brébeuf, the University of Ottawa (two camps, one in English, one in French), Brock University, the University of Western Ontario, the University of Manitoba, the University of Regina, the University of Alberta, and Simon Fraser University.

All sessions at the camps are given by local university professors and teachers on a voluntary basis. Local undergraduate and postgraduate students help as counsellors. Hence, costs are kept to a minimum, and funding received goes to pay direct costs such as meals, accommodation, supplies, and to a limited extent, travel expenses.

Mathematics camps receive support from the National Program Committee (CRM, Fields, PIMS), the Imperial Oil Charitable Foundation, NSERC PromoScience, several provincial ministries of education, the Canadian Mathematics Society, and the host universities.

**ESSO/CMS 2002 Mathematics Camp**

August 11–16, 2002

Held at Brock University

Director: Eric Muller (Brock)

For the third year, Brock University hosted an ESSO/CMS mathematics camp for Grade 9 and 10 students from Southwestern Ontario, including the greater Toronto area. As experience suggests that students thrive best through interaction with their peers, the camp was residential.

Students were invited to participate on the basis of their scores in the National Cayley and Fermat mathematical contests. The organizer aimed for representation from all areas of Southwestern Ontario and for equal numbers of male and female students, but ended up with seventeen boys and twelve girls. The high proportion of students not born in Canada was remarkable, including some who had been in Canada for less than a year.

A Sunday evening barbecue for the campers’ families led off events, providing parents a glimpse of the environment campers would experience the following week.

The camp was sponsored by the National Program Committee (CRM, Fields, PIMS), the Imperial Oil Charitable Foundation, the Canadian Mathematics Society, and Brock University. In addition, Brock generously provided an assistant, Dorothy Miners, whose help was invaluable to the success of the camp.

The scientific program was designed to impress these very bright students with the breadth of mathematics in the twenty-first century. A number of Brock faculty members (Henryk Fuk, Omar Kihel, Dorothy Miners, Eric Muller, and Bill Ralph) were invited to give lectures, presentations, and workshops in several different areas of mathematics—cryptography, statistics, topology, games and strategies, and problem solving, for example. Kevin Spry (Texas Instruments) also contributed to the scientific program.

The mathematical modelling activity associated with the Canadian Math Trail, begun in 2001, was continued this year. Campers were divided into small groups with two resource persons—a camp counsellor and a member of the Math Trail development team. After selecting a problem within their surroundings at Brock, teams worked on it for a limited time, and then developed a web page to explain their work. The result of this exercise is a Brock University Math Trail, which is part of the Canadian Virtual Math Trail and can be found by accessing the Trail and following links through Ontario http://www.BrockU.CA/cmt/ or, more directly, www.brocku.ca/cmt/upload/1029503738.121/

Renata Faber, an area teacher and graduate of Brock’s BSc/BEd Concurrent program, did an outstanding job of day-to-day activities. She set the tone for the camp on the first evening; she maintained throughout a level of discipline that enhanced every camper’s experience; and she developed and supervised all social activities. The other full-time camp counsellors, Margaret Macanowicz, Larry Moss, and Bruce Petrie, provided important help. In addition, Karlous Ravo and Steve Roach came in after work each day to assist with late afternoon activities and to share the nighttime responsibilities of a residence floor. Their work, together with that of Cathy Ugulini (Brock Mathematics Department’s Administrative Assistant), was invaluable.
CMS Canadian School Mathematics Forum
Forum canadien sur l’enseignement des mathématiques
May 16–18, 2003
Held at Université du Québec à Montréal

Chairs: George Bluman (UBC), Christiane Rousseau (Université de Montréal)

Public Lecture:
Jean-Marie De Koninck (Université Laval)

Plenary Speakers:
Deborah Ball (Michigan)
Hyman Bass (Michigan)
Jean-Pierre Kahane (Université de Paris-Sud, Orsay)
Frederick Leung (University of Hong Kong)

The Fields Institute was one of many sponsors of the two-day national meeting on mathematics education.

John Mighton, The Myth of Ability, and JUMP
On Wednesday, June 28, 2003 more than ninety people attended the launch of a book by John Mighton, The Myth of Ability: Nurturing Mathematical Talent in Every Child (House of Anansi Press, 2003). In The Myth of Ability, Mighton describes his method of teaching elementary mathematics, a groundbreaking approach developed during fifteen years of working with children from Toronto public schools. It is also the basis of the Junior Undiscovered Math Prodigies (JUMP) program, a volunteer-based tutoring organization that Mighton founded in 1998, which is housed at Fields.

Among those in attendance at the reception were Canadian author Michael Ondaatje and Annie Kidder from People for Education, JUMP tutors and students, mathematics teachers and administrators, and donors to the program.

From an original team of seven volunteers working with fifteen students, JUMP has grown in 2002–2003 to comprise two hundred and fifty volunteers and fifteen hundred students from twelve different Toronto schools. The main objective of the program is to provide underprivileged elementary school children with free access to tutoring in mathematics; an ancillary objective is to introduce systemic changes in their work habits and instil a sense of confidence and optimism that can last a lifetime.

Currently, JUMP runs two main programs: one delivering one-on-one tutoring and another providing in-class instruction with tutor support. JUMP also develops, writes, and produces all the custom materials used in its programs.

In partnership with other like-minded organizations, JUMP has recently undertaken some new initiatives:

- a twice-weekly tutoring program for young offenders with the York Detention Centre
- a two-week pilot project for grade 8 students in Regent Park with Pathways to Education
- a highly successful teaching pilot at a First Nations School in Mount Currie, B.C.
- locally-run JUMP chapters in Montreal, Ottawa, London, Halifax, and Sault Ste Marie

Canadian Centre for Research in Mathematics Education
In 2001, the Fields Institute created the Canadian Centre for Research in Mathematics Education. The Centre is a non-profit research organization that develops and assesses innovative approaches, tools, and technologies for the teaching and learning of mathematics in Canadian classrooms from kindergarten to grade 12.

In 2002–2003, the Centre raised funds for the support of five data management workshops through the use of the Fathom software project, which is licensed for use in all Ontario schools. The four-day workshops provided over 180 teachers with a hands-on learning experience that allowed them to translate their knowledge easily and effectively into classroom practice.

Gila Hanna (Fields), Kristina Reiss (Germany), Jürgen Richter-Gebert (Germany), and Jacobus H. van Lint (Netherlands) organized a workshop held at Oberwolfach, Germany (November 2–9, 2002) on Discrete Mathematics
and Proof in Mathematics Education, which was attended by nineteen participants. Proceedings will appear in *Zentralblatt fŸr Didaktik der Mathematik*.

A research project on using arguments from physics in mathematical proofs (grade 12 level) was carried out by Nathan Sidoli, Ysbrand De Bruyn, and Dennis Lomas. The aim of the study was to find out whether the use of concepts and arguments from statics can help students understand and prove geometrical theorems. The classroom experiment showed that most students were successful in using arguments from statics and that they gained a better understanding of the theorems as a result. Three papers presenting these results were published in the *Canadian Journal for Science, Mathematics, and Technology Education*, in *For the Learning of Mathematics*, and in the *International Reviews on Mathematics Education*.

Two proposals were prepared for the 2003 SSHRCC competition, one of which is a collaboration with Margaret Sinclair (York) and Walter Whiteley (York).

A small-scale project, Comparing Interactive Geometry Programs: Cinderella and Sketchpad, studied the suitability of Cinderella software to existing curriculum and whether it should be recommended for use in geometry classrooms. The project was partially funded by the Imperial Oil Centre at OISE. The research team consisted of Ysbrand De Bruyn, Gila Hanna, Nathan Sidoli, and Margaret Sinclair.
THE HONOUR OF BEING NAMED A FIELDS INSTITUTE FELLOW was established as a part of the Fields tenth anniversary celebration in 2002. It is a lifetime appointment for individuals who have made outstanding contributions to the Fields Institute and to the Canadian mathematical community. To the original group of thirty-three fellows, an additional seven were named in 2003. (See photo of new Fellows on page 30.) Listed below are the names of all Fields Fellows.

<table>
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<tr>
<th>Name</th>
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<tr>
<td>JAMES G. ARTHUR</td>
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<td>DAVID R. BRILLINGER</td>
<td>University of California–Berkeley</td>
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<td>ARTHUR CARTY</td>
<td>National Research Council</td>
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<td>JOHN CHADAM</td>
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<td>PETER FILLMORE</td>
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<td>ALAN GEORGE</td>
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<td>MARK GORESKY</td>
<td>Institute for Advanced Study</td>
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<td>STEPHEN HALPERIN</td>
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<td>GILA HANNA</td>
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<td>RICHARD KANE</td>
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<td>MANFRED KOLSTER</td>
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<td>FRANÇOIS LALONDE</td>
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<td>JERROLD E. MARSDEN</td>
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<td>JOHN MCKAY</td>
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<td>MOSHE A. MILEVSKY</td>
<td>IFID Centre and Schulich School of Business</td>
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<td>V. KUMAR MURTY</td>
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<td>NANCY REID</td>
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<td>LUIS A. SECO</td>
<td>Sigma Analysis and Management</td>
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<td>WILLIAM F. SHADWICK</td>
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<td>MICHAEL SIGAL</td>
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<td>VICTOR SNAITH</td>
<td>University of Southampton</td>
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<td>JAMES STEWART</td>
<td>McMaster University</td>
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Fields Institute Publications

Fields Institute Monograph Series
The Fields Institute Monographs Series (Series Code: FIM) features high-quality research monographs growing out of various activities at the Fields Institute located in Toronto, Ontario, Canada, including graduate course lectures and seminars. All Monographs are available for purchase from the American Mathematical Society On-line Bookstore—http://www.ams.org/cgi-bin/bookstore/bookpromo/fimseries (ISSN 1069-5273) Hardcover.

Listed by volume number


Forthcoming in the Fields Institute Monograph Series:
- Vertex operator Algebras and Their Representations, by C.Y. Dong.
### Fields Institute Communication Series

The Fields Institute Communications Series (Series Code: FIC) features proceedings and lecture notes growing out of the various activities at The Fields Institute for Research in Mathematical Sciences located in Toronto, Ontario, Canada. The publications evolve from each year’s main program. Interdisciplinary titles also emerge from programs and workshops focusing on applications of the mathematics in science, engineering, industry, and business. All Communications volumes are available for purchase from the American Mathematical Society On-line Bookstore—http://www.ams.org/cgi-bin/bookstore/bookpromo/ficseries (ISSN 1069-5265) Hardcover.

Listed by volume number

21 Differential Equations with Applications to Biology, eds. S. Ruan, Dalhousie University, G.S.K. Wolkowicz, McMaster University and J. Wu, York University, AMS, 1999, 509pp.
26 Monte Carlo Methods, ed. N. Madras, York University, AMS, 2000, 574pp.
38 Calabi-Yau Varieties and Mirror Symmetry, eds., N. Yui and J.D. Lewis, Queen's University, AMS 2003, 367pp.

Forthcoming in the Fields Institute Communications Series:
- Vertex Operator Algebras in Mathematics and Physics, S. Berman, Y. Billig and J. Lepowsky (Eds.)
- Representation Theory of Algebras, C. M. Ringel and V. Dlab (Eds.)
- Finite Dimensional Algebras and Related Topics, R. Buchweitz and H. Lenzing (Eds.)
- High Primes and Misdemeanours: Lectures in Honour of the 60th Birthday of Hugh Cowrie Williams, A.J. van der Poorten and A. Stein (Eds.)
- Difference and Differential Equations, J. Wu and X. Zou (Eds.)
- Asymptotic Methods in Stochastics: Volumes I and II, L. Horvath and B. Szyszkowicz (Eds.)
- Galois Theory, Hopf Algebras and Semiabelian Categories, G. Janelidze, B. Pareigis and W. Tholen (Eds.)
Our Directorate 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 mathematicians from Canada and abroad. The panel makes recommendations to the Board of Directors on the selection of thematic programs and workshops.

**WALTER CRAIG** received his MS and PhD from the Courant Institute of Mathematical Sciences, New York University. His research focuses on the theory of nonlinear partial differential equations and Hamiltonian dynamical systems, and their applications. He has taught at Caltech, Stanford University, and Brown University, and is currently Professor of Mathematics and Canada Research Chair at McMaster University. He has lectured extensively at conferences and institutes around the world, including the Tata Institute, the ICMS Edinburgh, the ETH, the INI, and IHES. He is currently on the Council of the AMS, and is a member of the editorial boards of the *SIAM Journal on Mathematical Analysis*, the *AMS Graduate Studies*, the *Proceedings of the Royal Society*, the *Canadian Journal of Mathematics*, the *Mathematical Physics Electronic Journal*, and the *Fields Institute Monograph Series*. He will help organize the Institute’s 2003 thematic program in Partial Differential Equations.

**KENNETH R. DAVIDSON** received his undergraduate degree at the University of Waterloo in 1972 and his PhD from the University of California at Berkeley in 1976. He was a C.L.E. Moore instructor at M.I.T. for two years before moving to the University of Waterloo in 1978. His research interests are in operator theory and operator algebras, and he won the Israel Halperin prize in this area in 1985. He was an E.W.R. Steacie fellow 1988–90 and a Killam Research Fellow 1995–97. He was elected a fellow of the Royal Society of Canada, the Institute of Mathematical Statistics, and the International Statistical Institute. He served as co-editor-in-chief of the *Canadian Journal of Mathematics* (1988–1993), and on the editorial boards of the *Annals of Probability* and the *Electronic Journal of Probability*. He will serve as president of the Bernoulli Society for Mathematical Statistics and Probability (2003–2005).

**DONALD A. DAWSON** received his Honours BSc 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 on the board of directors of the Carleton-Ottawa Laboratory for Research in Statistics and Probability since 1982 and served as Director of the Fields Institute from 1996 to 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 gave the 1991 Gold Medal Lecture of the Statistical Society of Canada, the 1994 Jeffery-Williams Lecture of the Canadian Mathematical Society, an invited lecture at the 1994 International Congress of Mathematicians in Zurich, and a plenary lecture at the 1996 World Congress of the Bernoulli Society in Vienna. He is a Fellow of the Royal Society of Canada, the Institute of Mathematical Statistics, and the International Statistical Institute. He served as co-editor-in-chief of the *Canadian Journal of Mathematics* (1988–1993), and on the editorial boards of the *Annals of Probability* and the *Electronic Journal of Probability*. He will serve as president of the Bernoulli Society for Mathematical Statistics and Probability (2003–2005).

**ANDREW GRANVILLE** completed his undergraduate education at Trinity College, Cambridge, and received his PhD from Queen’s University, Kingston. He is currently a Tier I Canada Research Chair at the Université de Montréal. He has also held visiting positions at Purkyne University, the Institute for Advanced Study, the Isaac Newton Institute, Universidad Autonoma, Madrid, the University of Michigan and the 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, he received the Hasse Prize from 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*, and the *Electronic Journal of Combinatorics*.
BRAD HART completed his term as the Deputy Director of the Fields Institute in July 2003. He received his undergraduate education at the University of Waterloo and earned 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 at 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.

LISA JEFFREY obtained her AB degree in 1986 from Princeton University, her MA from Cambridge University in 1988, and her doctorate in mathematics from the University of Oxford in 1992. She is currently Professor in the Department of Mathematics at the University of Toronto. Prior to her present appointment she taught at McGill University and Princeton University. Her research involves symplectic geometry and mathematical aspects of quantum field theory. She has received a Sloan Fellowship, a Premier's Research Excellence Award, the University of Toronto’s McLean Award, and the Aisenstadt Prize of the Centre de recherches mathématiques, as well as the 2001 Krieger-Nelson Lectureship and the 2002 Coxeter-James Lectureship of the Canadian Mathematical Society. She is a past member of the Council of NSERC, and is on the editorial board of the Transactions of the American Mathematical Society.

BARBARA LEE 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 John and Rebecca Moores Professor of Mathematics 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 Canadian Applied Mathematics Quarterly and Integrative Neuroscience, and is a co-editor-in-chief of Analysis and Applications.

ROBERT MIURA received his BS and MS in Mechanical Engineering from the University of California at Berkeley and his MA and PhD in Aerospace and Mechanical Sciences from Princeton University. He held postdoctoral positions at the Princeton Plasma Physics Laboratory and the Courant Institute. He has taught at New York University, Vanderbilt University, and the University of British Columbia, and currently is Professor of Mathematical Sciences and of Biomedical Engineering at the New Jersey Institute of Technology. His main research interests are in applied mathematics with applications to mathematical biology, especially excitable cells and physiology. He has been a John Simon Guggenheim Fellow and is a Fellow of the Royal Society of Canada. He has served on many editorial boards, and presently is on the editorial boards of the Canadian Applied Mathematics Quarterly and Integrative Neuroscience, and is a co-editor-in-chief of Analysis and Applications.

MICHAEL L. OVERTON received his BSc from UBC in 1974, along with the Governor General’s Gold Medal for Arts and Sciences. He received the MS and PhD degrees in Computer Science from Stanford University. He is currently Professor of Computer Science and Mathematics at the Courant Institute of Mathematical Sciences, New York University. He is an elected member of the Board of Trustees of SIAM (Society for Industrial and Applied Mathematics) and has also served on the SIAM Council. He is a member of the Council of FoCM (Foundations of Computational Mathematics) and of the Board of Directors of the Canadian Mathematical Society. He serves on the editorial boards of SIAM Journal on Optimization (for which he was editor-in-chief, 1995–99), SIAM Journal on Matrix Analysis and Applications, the IMA Journal on Numerical Analysis, SIAM Review, and ESAIM Journal on Control, Optimisation and Calculus of Variations. His research interests are at the interface of optimization and linear algebra, especially nonsmooth optimization problems involving eigenvalues, with applications to many different subjects including robust control, structural analysis, combinatorial optimization, and convex analysis. He is author of Numerical Computing with IEEE Floating Point Arithmetic (SIAM, 2001).
WILLIAM R. PULLEYBLANK is the Director of Exploratory Server Systems in IBM’s Research Division and the Director of the IBM Deep Computing Institute. He has also served as Director of Mathematical Sciences and as the Research Relationship 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 Advisory Committee of the NSF Mathematical and Physical Sciences Directorate, and Board of Directors of iCore. He is a member of the Advisory Council of the Pacific Institute for the Mathematical Sciences and is a member of the Industrial Advisory Committee of the Institute for Mathematics and its Applications where he 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.

BRUCE REED received his PhD from McGill University in 1986. He subsequently worked as a scientist or professor at Bell Communications Research, the University of Waterloo, Carnegie-Mellon University, and the CNRS in France. He was appointed to the Canada Research Chair in Graph Theory at McGill University in November 2001. He was an invited speaker at the International Congress of Mathematicians held in July 2002. His main research interests are in algorithmic graph theory and probabilistic combinatorics.

NANCY REID is Professor 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 Royal Society of Canada, 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 an ongoing interest in statistics for non-specialists, and on various aspects of “Statistics in the News.”

PETER SARNAK is a 1980 PhD graduate of Stanford University. He is Professor of Mathematics at the Courant Institute of Mathematical Sciences and is the Higgins Professor of Mathematics at Princeton University, where he served as chair (1996–1999). 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. In 2001, he was a winner of the Ostrowski Prize from the Ostrowski Foundation, Basel. In 2002, he was elected a Member of the National Academy of Sciences (U.S.A.) and a Fellow of the Royal Society (U.K.). He has served on the scientific advisory committees of the Mathematical Sciences Research Institute (Berkeley), the Institut des Hautes Études Scientifiques (Paris), and the National Science Foundation. In addition, he is on the editorial board of the *Annals of Mathematics* and of other leading research journals in mathematics, and has supervised twenty-seven doctoral students.

GORDON D. SLADE received the BASc and MSc degrees from the University of Toronto and the PhD from the University of British Columbia. His research interests are probability theory and statistical mechanics. He has been Professor in the Department of Mathematics at UBC since 1999, following thirteen years at McMaster University. He gave an Invited Lecture at the International Congress of Mathematicians in Zurich in 1994, was awarded the Coxeter-James Lectureship of the Canadian Mathematical Society in 1995, and was elected Fellow of the Royal Society of Canada in 2000. He was a co-organizer of the 1998–1999 Fields Institute thematic program in Probability and Its Applications.
McMaster University
McMaster University is a research-intensive, mid-sized university located in Hamilton at the west end of Lake Ontario. The Mathematics and Statistics Department has thirty-eight 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 twenty positions each year and a graduate program with over seventy 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 fifteen joint McMaster-Fields postdoctoral fellowships. PhiMac, a group of faculty, graduate students, and postdoctoral fellows dedicated to the theory and practice of financial mathematics, has received support from MITACS. The department has just established 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, linkage, and impact of mathematics at McMaster University and the larger community.

University of Ottawa
The Department of Mathematics and Statistics at the University of Ottawa is an active research department. It has about thirty-two faculty members with research grants, working in a wide range of areas, including algebra, analysis, applied mathematics, logic and foundations of computing, number theory, statistics, probability, and topology. The department is home to a Canada Research Chair in mathematical genomics, to a Fellow of the Royal Society of Canada (FRSC), and to two holders of Ontario Premier’s Researcher Excellence Awards (PREA). The department has a vibrant graduate program joint with Carleton University, with currently about forty graduate students at the University of Ottawa. In addition to offering MSc and PhD degrees in traditional areas, the department also offers an MSc program in Biostatistics, joint with the Department of Epidemiology, as well as an MSc in High Technology. Besides being a member of the Fields Institute, the department is also a member of the Centre de recherches mathématiques (CRM). The department is also proud of its postdoctoral program, which now provides about twelve postdoctoral positions. The University of Ottawa is a bilingual institution in the heart of Canada’s capital. The department benefits from its proximity to the government, with a number of appointments of adjunct professors who are active mathematicians affiliated with Canadian research agencies.

University of Toronto
Research and teaching in mathematics is carried out at the University of Toronto in the Departments of Computer Science, Mathematics, and Statistics, with a combined total of over one hundred and forty faculty members. The Department of Computer Science was the first computer science department established in Canada, and is characterized by its breadth of research and teaching interests, and the high quality of its faculty and graduate students. Faculty members have won many important prizes and awards, including the Turing Award (S.A. Cook) the Fulkerson Prize in Discrete Mathematics (A. Lehman), the IJCAI Award for Research Excellence (R. Reiter) and the Order of Canada (C.C. Gotlieb). The department has produced a large proportion of the computer science Ph.D.s in Canada, and has contributed faculty members to many departments in Canada and abroad. The Department of Computer Science has strong ties with the Fields Institute. Members of the department have played a central role in several Fields programs, including the recent thematic program on Numerical and Computational Challenges in Science and Engineering (2001–2002).

The Department of Mathematics at the University of Toronto is one of the leading mathematics research departments in Canada. Mathematics has been taught there since 1827, and the department’s first PhD was conferred in 1915 on Samuel Beatty—a student of John Charles Fields, whose will established the Fields Medal and after whom the Fields Institute is named. Research in the department 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 through the highest research grant average in Canada, 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 department is involved with the Fields Institute at all levels—through participation in its workshops and thematic programs, in events for high school teachers, and collaborative research projects within MITACS.

The Department of Statistics was established in 1977, and offers programs in actuarial science, statistics, and probability. The department has a long history of innovation and advance in the theory and foundations of statistics, and is among the leading theoretical departments in the world. It has also been for many years at the forefront of developments in statistical computing, and maintains exceptionally strong ties with the biostatistics research group in the Department of Public Health Sciences. Research activity in probability, theoretical statistics, and methods of applied statistics is vigorous and growing, and the department has recently established a research cluster of Canada Research Chairs in data mining and machine learning, jointly with the Department of Computer Science.

**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 over four thousand full-time undergraduate and three hundred graduate students, and one hundred and sixty 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 units: 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 and quantum computation have become major strengths in the Faculty. The Faculty of Mathematics generated $15.8 million in research funding last year. With the University’s liberal position on intellectual property, research conducted in the Faculty has resulted in over one hundred spin-off companies founded by professors, students, and graduates. Known for its mathematics and computer contests, the success of its graduates, and its high standards, the Faculty of Mathematics consistently attracts the best students from around the world. Waterloo has placed among the top ten schools in each of the past nine years in the Association for Computing Machinery (ACM) International Programming Competition. It has been the world champion twice (1994, 1999) and North American champion four times during that period. As well, the University has placed in the top ten in the Putnam Competition thirteen times in the past fourteen years, placing first in 1999 and sixth in the most recent competition. Waterloo routinely ranks among the top three or four schools in terms of the number of students who place in the top two hundred in that competition. For ten years in a row, a group of more than three thousand senior administrators, company presidents, and academic counsellors surveyed by *Maclean’s 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, noncommutative 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 queueing 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, including two Canada Research Chairs. 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), mathematical modelling and numerical analysis, algebra and geometry, financial mathematics, 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 U.S.-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. 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). 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. An MSc program in Industrial and Applied Mathematics was begun in 2002. 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.
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Financial Report

The financial statements for the year ending March 31, 2003, show that the Institute is in a strong financial position. We had increased support from various sources for scientific activity, and thus were able to increase our support without significantly affecting our operating expenses. Our net surplus is small, consistent with our aim to develop as many activities as we can afford, yet we go into the new year with a modest surplus. The budget for the coming year projects a similar position for the coming year.

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

The University has licensed the Institute to use the premises located in Toronto, Ontario and charges the Institute an annual "Block Fee" of $5 space and services.

4. OTHER EDUCATIONAL INITIATIVES

JUMP [Junior Undiscovered Math Prodigies] is a volunteer, math tutoring program providing free tutoring in mathematics to children identified as havin
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, 2003 and the statement of operations and surplus 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 Canadian generally accepted auditing standards. Those standards require that we plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In our opinion, these financial statements present fairly, in all material respects, the financial position of the Institute as at March 31, 2003 and the results of its operations and its cash flows for the year then ended in accordance with Canadian generally accepted accounting principles.

Toronto, Canada,
May 9, 2003.

Ernst & Young LLP
Chartered Accountants
The Fields Institute for Research in Mathematical Sciences

**BALANCE SHEET**

As at March 31

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td><strong>ASSETS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Due from University of Toronto [note 3]</td>
<td>216,320</td>
<td>272,883</td>
</tr>
<tr>
<td>Accounts receivable</td>
<td>159,928</td>
<td>129,580</td>
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<tr>
<td>Goods and Services Tax receivable</td>
<td>14,681</td>
<td>32,840</td>
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<tr>
<td>Prepaid expenses</td>
<td>7,420</td>
<td>10,368</td>
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<tr>
<td><strong>Total</strong></td>
<td>398,349</td>
<td>445,671</td>
</tr>
<tr>
<td><strong>LIABILITIES AND SURPLUS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accounts payable and accrued liabilities</td>
<td>99,459</td>
<td>91,739</td>
</tr>
<tr>
<td>Deferred revenue</td>
<td>66,843</td>
<td>180,958</td>
</tr>
<tr>
<td><strong>Total liabilities</strong></td>
<td>166,302</td>
<td>272,697</td>
</tr>
<tr>
<td>Surplus</td>
<td>232,047</td>
<td>172,974</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>398,349</td>
<td>445,671</td>
</tr>
</tbody>
</table>

*See accompanying notes*
The Fields Institute for Research in Mathematical Sciences

STATEMENT OF OPERATIONS AND SURPLUS

Year ended March 31

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td><strong>INCOME</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Sciences and Engineering Research Council of Canada</td>
<td>1,104,295</td>
<td>1,045,197</td>
</tr>
<tr>
<td>Ontario Ministry of Training, Colleges and Universities</td>
<td>1,000,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Other scientific program grants</td>
<td>370,699</td>
<td>194,495</td>
</tr>
<tr>
<td>Sponsoring revenue</td>
<td>350,910</td>
<td>161,000</td>
</tr>
<tr>
<td>Commercial/industrial mathematics grants</td>
<td>119,888</td>
<td>100,738</td>
</tr>
<tr>
<td>Registration fees</td>
<td>93,163</td>
<td>32,045</td>
</tr>
<tr>
<td>Recovery of indirect costs [NSERC]</td>
<td>91,073</td>
<td>—</td>
</tr>
<tr>
<td>MITACS</td>
<td>83,803</td>
<td>95,807</td>
</tr>
<tr>
<td>Publications</td>
<td>39,805</td>
<td>48,945</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>26,315</td>
<td>5,827</td>
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<tr>
<td>Mathematics Education grants</td>
<td>18,500</td>
<td>—</td>
</tr>
<tr>
<td>Donations [note 4]</td>
<td>11,290</td>
<td>46,909</td>
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<tr>
<td>Interest</td>
<td>4,722</td>
<td>21,397</td>
</tr>
<tr>
<td></td>
<td>3,314,463</td>
<td>2,752,360</td>
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<tr>
<td><strong>EXPENSES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific program</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visitor's expense</td>
<td>671,368</td>
<td>510,210</td>
</tr>
<tr>
<td>PDF salary</td>
<td>603,002</td>
<td>280,895</td>
</tr>
<tr>
<td>General scientific expenses</td>
<td>117,346</td>
<td>173,199</td>
</tr>
<tr>
<td>Guest - teaching and lecture fee</td>
<td>62,632</td>
<td>1,454,348</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salaries and benefits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific and support staff</td>
<td>407,574</td>
<td>394,344</td>
</tr>
<tr>
<td>Directorate</td>
<td>340,101</td>
<td>281,700</td>
</tr>
<tr>
<td>Administrative support staff</td>
<td>294,487</td>
<td>1,042,162</td>
</tr>
<tr>
<td>Professional services</td>
<td>15,525</td>
<td>107,118</td>
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<tr>
<td>Rent and services [note 3]</td>
<td>530,795</td>
<td>526,940</td>
</tr>
<tr>
<td>Equipment</td>
<td>69,860</td>
<td>81,169</td>
</tr>
<tr>
<td>Communications</td>
<td>44,282</td>
<td>39,234</td>
</tr>
<tr>
<td>General and office supplies</td>
<td>43,091</td>
<td>41,953</td>
</tr>
<tr>
<td>Administrative expenses</td>
<td>26,167</td>
<td>43,031</td>
</tr>
<tr>
<td>Printed material and publishing</td>
<td>17,870</td>
<td>15,250</td>
</tr>
<tr>
<td>Other educational initiatives [note 4]</td>
<td>11,290</td>
<td>46,909</td>
</tr>
<tr>
<td></td>
<td>3,255,390</td>
<td>2,837,429</td>
</tr>
<tr>
<td><strong>Net surplus (deficit) for the year</strong></td>
<td>59,073</td>
<td>(85,069)</td>
</tr>
</tbody>
</table>

Surplus, beginning of year 172,974 258,043

Surplus, end of year 232,047 172,974

See accompanying notes
The Fields Institute for Research in Mathematical Sciences

NOTES TO FINANCIAL STATEMENTS

March 31, 2003

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 research in the mathematical sciences. The Institute's mandate includes programs devoted to leading-edge research in the mathematical sciences; advancement in mathematics education; enhanced graduate and post-doctoral training opportunities; and developing partnerships with industry to encourage technology transfer.

During 2000, the Institute received charitable tax status.

2. SIGNIFICANT ACCOUNTING POLICIES

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

Revenue recognition

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

NOTES TO FINANCIAL STATEMENTS

March 31, 2003

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

4. OTHER EDUCATIONAL INITIATIVES

JUMP [Junior Undiscovered Math Prodigies] is a volunteer, math tutoring program committed to providing free tutoring in mathematics to children identified as having difficulty succeeding in mathematics. The Institute received donations on behalf of JUMP and processed expenses against these receipts. During 2002, JUMP received charitable tax status and started to receive and process donations directly.

5. 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.

6. FINANCIAL INSTRUMENTS

The carrying amounts of due from University of Toronto, accounts receivable, accounts payable and accrued liabilities and deferred revenue on the balance sheet approximate their fair values due to the short-term nature of these instruments.

Credit risk on financial instruments is the risk of financial loss occurring as a result of default of a counterparty on its obligation to the Institute. Credit risk is managed by dealing only with counterparties the Institute believes to be creditworthy.