

# Mathematics



Department of Mathematics

University of Toronto

February 2005

## From the Chair



Prof. Jeremy Quastel, Acting Chair

It has been an honour to serve as Acting Chair this year while John Bland is taking a well-deserved sabbatical. I have had the privilege of working with many able fellow administrators: Yael Karshon, who is serving as Associate Chair; Mike Lorimer, our continuing Associate Chair — Undergraduate; and Catherine Sulem, the new Graduate Coordinator. And I don't know what I would do without the help of our

wonderful staff, led by Beverley Leslie, who keep the department running smoothly.

Perhaps the most exciting new development this year is the planned move of the entire mathematics department to the 6th floor of the Bahen Centre for Information Technology together with one floor of 215 Huron Street, connected by a bridge between the two buildings. The Bahen Centre was constructed a few years ago just to the north of the bookstore at College and St. George. The move will create a community of mathematical sciences at the south end of the St. George campus, with Computer Science and Electrical Engineering already partly located in the Bahen Centre, Statistics planning to move into 215 Huron, and the Fields Institute just a stone's throw away to the south. As the department has grown in the last few years, whole groups have been relocated to other buildings on campus owing to space limitations at Sidney Smith. While the growth of course has been wonderful for the department, the disconnectedness has threatened to affect the research and training environment negatively. The planned move to Bahen will bring everyone together in attractive and connected space, with a large library and enhanced seminar room and lounge. Construction will start in 2005 and we expect to be moving in 2007.

The move to Bahen is just part of our success story in the past few years. The department has changed so much since I came here seven years ago! World class research groups

## CONTENTS

From the Chair .....	1
Mathematics in the Sky.....	2
Alumni News .....	3
Barbara Keyfitz — Change and Challenge .....	4
Our Undergraduates.....	4
The Coxeter Legacy — Reflections and Projections .....	6
The Coxeter Concert .....	7
New People in the Department.....	7
Outstanding Faculty .....	7
<i>Ragnar-Olaf Buchweitz</i>	
<i>Lisa Jeffrey</i>	
<i>Balint Virág</i>	
<i>James Arthur</i>	
<i>Ed Bierstone and Pierre Milman</i>	
The James Arthur Conference .....	8
The 2005 Blyth Lectures — Yuri Manin .....	9
The Graduate School: Theses and Awards.....	10
Public Lecture Hendrik W. Lenstra Jr. ....	11
Deaths in the Department.....	11

### EDITORS

Erich W. Ellers, George A. Elliott

### CONTRIBUTORS

Robert Almgren, Edward J. Barbeau, Ida Bulat, Katia Consani,  
Christie Darville, Abe Igelfeld, Karen Kelly, Barbara L. Keyfitz,  
Diana Kuprel, Fiona Murnaghan, Jeremy Quastel, Peter Rosenthal

have been created from scratch (dynamical systems) or built out of existing strength (symplectic geometry, partial differential equations). And of course there have been wonderful new colleagues outside these groups. The postdoctoral program has expanded, and we now host up to 30 postdocs each year. The graduate program has also been very successful; we are very fortunate that the graduate school has instituted a guaranteed funding package for Ph.D. students. The environment for research and training has become the envy of our competitors, who are increasingly the very top public research universities in the world.

One key initiative we are developing over the coming years is to institute a program of prestigious, named Assistant Professorships to allow young researchers to spend several years in our research-intensive environment before moving on to tenure track positions. Such positions require substantial endowed funds and we are planning to start fundraising soon.

One of the great pleasures of being Acting Chair this year has been the opportunity to appreciate so directly the excellence of our faculty and students, and to witness the dedication and support of alumni and friends of the mathematics department, who have helped us get where we are. I believe the future holds even greater things for mathematics at the University of Toronto.

J. Q.

---

## Mathematics in the Sky

Yes, there is, when you have a team of mathematicians, husband and wife, who both know that they find an interesting application of partial differential equations in their favorite sport. Rob Almgren and Agnes Tourin are professors of mathematics. Rob is a member of our department and works in applied mathematics in general, and Agnes is at McMaster University in Hamilton. She is an expert in Hamilton-Jacobi-Bellman (HJB) partial differential equations and non-smooth solutions.

Rob tells us: "I gave a public talk together with Agnes on November 7, 2004, at the *Royal Canadian Institute* on *The Mathematics of Glider Racing*. It was based on our recent joint paper on the same subject.

Glider travel cross-country by looking for rising columns of warm air. At each point in the flight, there is great uncertainty about where the next rising air will be found and how strong it will be. Thus the pilot faces the choice of when to press onwards at high speed, and when to stop and use the local lift. One can formulate the problem mathematically using the theory of stochastic processes, and then, using dynamic programming, the decision problem leads to a nonlinear HJB equation with an internal free boundary. The mathematical tools to solve this type of problem have been heavily developed over the last



twenty years, because of the importance of similar equations in finance, in image processing, and in front propagation in physical systems.

The Royal Canadian Institute has been promoting the public understanding of science since its founding in 1849, and currently offers about a dozen lectures annually. In recent years it has been working with the Fields Institute to include a few mathematics talks in areas that are accessible to a broad audience. In this case, the subject of glider racing was an opportunity not only to show nice pictures, but also to follow a specific problem through the classic stages of identifying the problem, constructing a suitable mathematical model, and bringing to bear mathematical techniques developed for a broad class of similar problems."

R. A.

---

# Alumni News

To all our alumnae and alumni, please send us NEWS about yourselves that you would like to share!

Here are some very good ones.

## Barbara Lee KEYFITZ

Not only has Alumna Professor Barbara Lee Keyfitz of the University of Houston, Texas, been chosen to be the new Director of the Fields Institute for the next three years, but also the Canadian Mathematical Society (CMS) has selected Barbara Keyfitz as the recipient of the 2005 *Krieger-Nelson Prize*. The Krieger-Nelson Prize recognizes outstanding research by a female mathematician.

## Robert V. MOODY

The University of Toronto in June 2004 bestowed an HONORARY DOCTORATE on Robert V. Moody, now Professor of Mathematics at the University of Alberta in Edmonton. He received his Master's degree and Ph.D. from the University of Toronto. He has since become famous for a discovery which has far-reaching consequences. He, and independently the Russian mathematician Victor Kac, noticed that some algebras existed which can be used widely in theoretical physics. These algebras now bear the name *Kac-Moody* algebras.

Robert Moody has been a leader in modern mathematics for a long time now. He played a large role in the development of the *Banff International Research Station for the Mathematical Sciences*, where he served as its first scientific director. He has sat on numerous advisory panels, among them at the *Fields Institute for Research in Mathematical Sciences* in Toronto.

In May 2004, Robert Moody was one of the key speakers at our conference on *The Coxeter Legacy — Reflections and Projections*. His talk "Non-crystallographic Coxeter groups and quasicrystals" described his new results and exciting goals in this fascinating area. The title of the talk indicates perhaps, as he mentioned, how his "interaction with Donald Coxeter was to profoundly affect my [his] mathematical career".

E. W. E.

## Ralph Lee PATTON

a.k.a. Brother L. Raphael, FSC — a.k.a. MAX

Max, as everybody used to call him, got his Ph.D. in Mathematics here in Toronto in 1977. He is now Professor of Mathematics at Saint Mary's College of California in Moraga, CA, and Senior Tutor of their *Integral Program*.

Last summer, Max sent us the following brief description, in his unique personal style, of much of his life since his student days.

"Just finishing a second term as Director of the Integral Program, the Great Books curriculum here at Saint Mary's, with about 80 to 90 students. Last year finished a second term as chairman of the Department of Mathematics and Computer Science, handing the whole thing over to Jim Sauerberg. Having returned to the ranks, will be teaching a couple of low-level math courses in the fall.

This is my 34th year on the faculty at Saint Mary's College. Spent some time in Toronto in Sid Smith with Erich Ellers and Donald Coxeter.

G. Duff was chairman in those days. Worked in tandem with Georg Günther, now of Memorial, Newfoundland. Finished up in linear geometry and headed back to California. Worked 1992 – 1995 in Nairobi setting up a small teacher-training college at Tangaza. Served as Visiting Professor of Mathematics and Astronomy at Saint Mary's University in Minnesota, 1995 – 1998. Have been back at my post since then.

Just now the front porch, the rocking chair and a good cigar are looking increasingly attractive."

Br. L. R. (FSC)

## GIVING TO THE DEPARTMENT OF MATHEMATICS

Our alumni have always shown great interest in the performance of our department. We are grateful for their continuing support, which is indicative of the value they place in the education they received here and the quality of their academic experience. Their generosity, understanding, and vision are vital in helping us to attract the most talented students from across Canada and around the world, and giving them the encouragement to pursue their educational goals and the means to excel in their chosen field.

The *Mathematics Departmental Trust Fund* is a crucial source of discretionary funds to which the Chair has access to support departmental academic priorities. One of the uses to which this fund is put is to supplement scholarships and bursaries, which enables the Chair to recognize undergraduate and graduate students who demonstrate exceptional achievement in mathematics and to assist deserving students in financial need.

We welcome contributions towards the *Mathematics Departmental Trust Fund*.

When our alumni invest in the education — and aspirations — of young scholars, they are playing an important role in the success of future generations of mathematicians, by helping us create a strong, vibrant community in which learning and scholarship flourish.

Thank you for your support.

D. K., C. D.

# Barbara L Keyfitz — Change and Challenge

For the next three years, Barbara Keyfitz will be the Director of the Fields Institute. She is one of our alumnae but made her mathematical career in the United States and is now Professor at the University of Houston, Texas. Here she tells us what “coming back” to Toronto means to her:



Barbara L. Keyfitz

“People hasten to point out how much Toronto has changed since I left. I am much more aware of how I have changed.

Returning, I am newly aware of the high quality of the education I received here — and this is something that has not changed. There are new faces in the Mathematics Department,

though it is wonderful to see some of the people who influenced me as a student, like Chandler Davis and Tim Rooney. And Jim Arthur, who was my fellow student when we were undergraduates from 1962 to 1966, could, like me, also claim to have changed.

More than the new faces, it is the new kinds of faces, and voices, and the diversity of cultures and languages, that are striking when one walks around the campus. But even if people dress differently and put ornaments in their eyebrows, it is here, in the same buildings where I first grew into adulthood, that a new generation is experiencing the same adventure. The reasons I needed to leave Toronto in 1966 seemed specific to me: there was little possibility to study Partial Differential Equations in Toronto then, and little encouragement for women to enter graduate school at all. For too long I was more conscious of what seemed like a forced exile than of the fact that changing one’s horizons is a necessary part of growing up. The things that seemed then to make me an exception, now seem like the beginning of a definition of a career, and of a life.

Living again in the city where I was young brings a richness of association and of recollection to daily life. It colours new friendships as much as it revives old ones.

In 1966, I was excited to leave Toronto to seek out new challenges. In 2004, I am just as excited to be here again, and for the same reason.”

B. L. K.

# Our Undergraduates

## OLYMPIC SUCCESS

While the world stands transfixed by this summer’s Olympic swimmers and sprinters, another type of Olympics was also held in Athens this summer (July 4 to 18): the 45th *International Mathematical Olympiad* (IMO). Thanks to the efforts of Jacob Tsimerman, Canada has one more medal to add to its Olympic glory.



Jacob Tsimerman

Tsimerman, who graduated from University of Toronto Schools (UTS) and will study pure mathematics at U of T this fall [2004], achieved a perfect score of 42 out of 42. While he felt confident with his answers, he didn’t expect a flawless score. “I was a little bit surprised,” says the 16-year-old, who shared first-place

honours with 45 other individual medallists. “I knew that I was going to get close to perfect, but there was one question I thought I might’ve left something out, sometimes it’s hard to know what’s trivial.”

To qualify for the IMO, Tsimerman first competed in three other contests: the Canadian, the Asian-Pacific, and the U.S. Olympiads. After achieving top marks in these competitions, Tsimerman moved on to Athens where he completed six complicated math questions in two days. On each day, competitors had to answer three questions within the allotted four and a half hours.

“It seems like you’re given a lot of time for just three questions but it goes by very quickly,” Tsimerman says. “I break the [questions] down first and play around with them for about half an hour and then go for something more concrete. It’s important to balance your time.”

Practising for the Olympiad meant concentrating on his professed weakest area of math: geometry. Tsimerman began by surfing the Internet in search of geometric stumbers to solve. “You mostly look at past calculations that you know you’re going to find in the Olympiad,” Tsimerman says. “I was really bad at geometry about a year ago — well, really bad by these standards — and I spent a lot of time working with geometry.”

It appears that Tsimerman has been practising all his life. When he was young, his grandfather, a physicist, honed his budding mathematical skills by sitting Tsimerman down to answer math questions. “It was really just for fun but that’s where it started,” says Tsimerman, who was born in Russia, moved to Israel when he was two and then moved again, to Canada, seven years ago.

While competing in the IMO is open to high school students under 20, Tsimerman will be ineligible to compete next year as he is attending university.

The IMO was first held in Romania in 1959 and had six competing countries. Since then it has grown to include 85 countries with 480 students. This year, Team Canada — which included another UTS student now at U of T, **Janos Kramer**—placed 21st out of 85 competing teams and China took the top prize.

K. K.

This article was originally published under the heading 'Gold in the Numbers Game' in *The Bulletin*, University of Toronto, August 23, 2004, 58th Year, Number 2. The photo was taken by Pascal Paquette of *The Bulletin*.

### THE 2003 PUTNAM CONTEST

*Five of the top sixteen are from Canada.*

Canadians again performed well in the 64th Putnam Competition, written on December 6, 2003. Ralph C. Furmaniak of the University of Waterloo was a Putnam Fellow, one of the top five students. Among the next highest ranking students were:

David G. Arthur of Duke University, Robert M. Barrington Leigh of the University of Toronto, Alex R. Fink of the University of Calgary, and David A. G. Pritchard of the Massachusetts Institute of Technology.

Honorable mention was accorded to:

Daniel S. Brox of the University of British Columbia, Pierre Le Van of the University of Ottawa, Tianyi David Han and Roger Mong, both of the University of Toronto, and Lino M. Demasi of the University of Waterloo.

Three Canadian teams received honorable mention (ranking between sixth and tenth inclusive):

University of Waterloo (Olena Bormashenko, Lino M. Demasi, Ralph C. Furmaniak),

University of Toronto (Robert M. Barrington Leigh, Ali Feiz Mohammadi, Roger S.K. Mong), and

University of British Columbia (Daniel S. Brox, Nina Kamoosi, Max Motlitski).

Congratulations to all of the students on a fine achievement!

In all, 3615 students from 479 North American post-secondary institutions participated, including 401 teams. Among the top 210 students were 27 from eight Canadian universities in five provinces.

E. J. B.

### THE U OF T UNDERGRADUATE CONTEST

The fourth annual University of Toronto Undergraduate mathematics competition was written on Sunday, March

14, 2004. There were eighteen candidates from the Faculties of Arts & Science and Applied Science & Engineering.

The following students received top ranking:

1. Garry Goldstein (II Arts & Science Mathematics)
2. Ali Feiz Mohammadi (I Engineering Science)
3. Robert Barrington Leigh (I Arts & Science Mathematics)
4. Roger Mong (II Engineering Science)

The following students, in alphabetical order, received honourable mention:

Samuel Huang (IV Engineering Science), Emily Redelmeir (Arts & Science, Mathematics), David Shirokoff (II Engineering Science), and Ilya Sutskever (III Arts & Science, Computer Science).

Congratulations to all of these students for a job well done!

I am indebted to Professor Man-Duen Choi for checking the ranking of the top papers.

This annual contest is an open competition, and any undergraduate at the University of Toronto may write it.

The questions and solutions to the first four papers can be found on the website [www.math.utoronto.ca/barbeau/](http://www.math.utoronto.ca/barbeau/). You will need an Acrobat Reader.

E. J. B.

### DELURY TEACHING AWARDS

Abe Igelfeld, the Teaching Assistant (TA) Coordinator, is happy to announce that for the year 2003 – 2004 the winners of the DeLury Teaching Awards for excellence in TA work were:

Ching-Nam Hung, Cristian Ivanescu, and Brian Robin. The selection committee consisted of Man-Duen Choi, Mike Lorimer, and Abe Igelfeld.

There is a lot of excellent work being done by our TAs.

We would like to congratulate the winners!

A. I.

---

## The Coxeter Legacy — Reflections & Projections

MAY 12 — 16, 2004 A CONFERENCE

This conference was held in honour of H. S. M. Coxeter (1907 – 2003) to reflect on his legacy, emphasizing his main achievements, demonstrating the impact of his ideas on current research, and exploring future directions suggested by his work.



H. S. M. Coxeter

The conference was sponsored by the University of Toronto, the Fields Institute, and the Canadian Mathematical Society.

The festivities included an evening of two public lectures, a concert hosted by the Fields Institute in the beautiful atrium of the institute, and a banquet.

Coxeter's daughter, Susan Coxeter Thomas, and Alison Conway of the Fields Institute organized a display of Coxeter memorabilia in

the hall in front of the auditorium in which the lectures took place. This created a personal atmosphere at the main meeting place.

Among the displayed articles were mathematics books written by Coxeter, to be given away on this occasion. One of our invited speakers, a Russian, found three such books there, translated into the Russian language — Russian editions. Susan Coxeter Thomas made our guest very happy by signing them for him. Later, he started his talk by holding the books up high and telling this little story which he ended emphatically with a happy smile, "I shall treasure them forever!"

There were twenty-three invited speakers from several countries, prominent mathematicians in their fields.

These talks will result in survey articles to be published in the AMS/Fields *Communications Series* under the title of the conference, "The Coxeter Legacy — Reflections and Projections".

We also had contributed talks of 20 minutes each, on diverse topics concerning Coxeter's legacy.

We can identify four main areas that were influenced by Coxeter's research: *Coxeter groups*, *Polytopes*, *Visual Arts*, and *Packings*. We invited eminent experts in these fields to reflect on important achievements and to project and give directions for further developments.

*Coxeter groups* are the basis for many structures that are investigated by mathematicians. They play a unifying role in representation theory. In geometry they occur naturally as groups that are generated by reflections in hyperplanes. In this setting, Coxeter encountered the groups that now bear his name. He saw their significance, he classified them, and he described them by easily recognizable diagrams, the *Coxeter diagrams*. We come upon Coxeter groups in the study of Lie algebras, algebraic groups, Chevalley groups, Kac-Moody groups, polytopes, crystallography, operator algebras, and in many other disciplines. They reveal the symmetry of the object under consideration.

Coxeter was fascinated with *Polytopes*. He instilled the love for them in all his students. Today the study of polytopes is thriving. We had a great number of experts at the conference so that we got a global picture of today's state of

the subject. The combined effort of the participants of this conference will deliver an up-to-date complete description of our knowledge of polytopes in the conference proceedings. It promises to become a modern standard reference book, just as Coxeter's book *Regular Polytopes* has been since it was first published in 1948.

Coxeter was attracted by symmetry and beauty. So it is no wonder that he appreciated the *Visual Arts*. He was particularly intrigued by M. C. Escher's drawings. There he could see, for example, a connection to the tiling of a hyperbolic space, a direct link between art and mathematics. In the public lectures at our conference, through many pictures and a film, we got a glimpse of this aspect of mathematics and its impact on the world around us. We also had a talk by one of the creators of a very versatile and impressive computer program "Cinderella" which brings geometric configurations to life.

The mathematical area of *Packings* has surprising consequences. It is possible to fill space with cubes but obviously not with balls. How much of the space can we fill by cleverly stacking balls? That is one of the questions Coxeter was interested in. This problem and its connection to error correcting codes was discussed in some of the presentations at our conference.

To sum up, Coxeter's ideas had amazingly wide-reaching consequences. We endeavoured to capture the essence of Coxeter's work in our conference and to show the still ongoing development of a great number of mathematical fields that grew from it.

E. W. E.

## The Coxeter Concert

MAY 14, 2004



H. S. M. Coxeter

A festive event at the *Coxeter Legacy* conference.

Coxeter's legacy lingers at the Fields Institute. Interlocking triangles at the entrance remind the visitor of the cele-

bration of Donald's 90th birthday. A projection of a regular 4-dimensional solid, a subject of Donald's dreams already in his youth, adorns the ceiling by the beautiful staircase in the atrium, donated to recognize his 95th birthday. A grand piano stands in the hall — not any ordinary piano, but Donald's own, the one on which he played his first tunes when he was just three years old.

The concert program consisted of a quintet for piano and strings by Robert Schumann and four pieces composed by Coxeter himself, giving testimony that in his youth Donald had wavered between two possible professions: musician or mathematician.

The team of musicians was led by Catherine Sulem who is not only an accomplished violinist but also professor in the Department of Mathematics at the University of Toronto. The other four instrumentalists were Niky Kamran (violin), Charles Small (viola), Eric del Junco (cello), Sydney Bulman-Fleming (piano). They, too, are mathematicians at Canadian universities. Soprano Anne Morrone is a staff member at the Fields Institute.

The photo shows Donald Coxeter, age 3, at "our" piano. It depicts a detail of an oil painting by his mother. This piano was donated to the Fields Institute by Coxeter's daughter, Susan Thomas.

E. W. E.

---

## New People in the Department

We are happy to welcome:

Professor Ilia Binder who comes to Toronto from the University of Illinois at Urbana-Champaign. Effective July 1, 2004, he accepted the tenure-stream position in Applied Partial Differential Equations in the Department of Mathematical and Computational Sciences at UTM, the University of Toronto at Mississauga.

Ilia spent part of his time in Urbana as Visiting Assistant Professor at Yale University and also visited the Mittag-Leffler Institute in Sweden. After his Ph.D. at the California Institute of Technology in 1997, he spent four years at Harvard University as Benjamin Peirce Assistant Professor. Ilia was a Member of the Institute for Advanced Study in 1998 – 1999. His research interests include Geometric Function Theory, Complex Analysis and Potential Theory, Complex Dynamics, Percolation Theory, and Multifractal Analysis.

We welcome two new members of our administrative staff:

Jemima Merisca started working for our department on November 8, 2004, as Department Secretary. She is replacing Nadia Villani who had been with us since 1989. Nadia was a great help to all of us.

Diana Leonardo is our new Receptionist. She started on November 15, 2004, and is replacing Amanda Rogers who is now pursuing a law degree at the University of Windsor.

E. W. E.

---

## Outstanding Faculty

### RAGNAR OLAF BUCHWEITZ

We are pleased to announce that our colleague Professor Ragnar-Olaf Buchweitz has been appointed *Vice-Principal (Academic) and Dean* at the University of Toronto at Scarborough, for a five-year term, beginning July 1, 2004, and ending June 30, 2009. Ragnar has been a valuable member of our Department of Mathematics and a well-liked colleague for many years.

Professor Buchweitz received his Ph.D. (Dr. rer. nat.) from the Universität Hannover in 1976 and Docteur d'État ès Sciences Mathématiques from Université Paris VII in 1981. He was an Assistant Professor of Mathematics at Brandeis University in the U.S.A. from 1981 to 1983, and a *Heisenberg-Scholar* of the *Deutsche Forschungsgemeinschaft* (DFG) in Germany from 1984 to 1987. He joined the University of Toronto in 1987, and served as Associate Chair (1999 – 2000) and then Acting Chair (2000 – 2001) of the Department of Mathematics. He has served as Vice Dean at UTSC since 2001. Ragnar has published numerous articles and has received many awards and grants from NSERC, the German Research Council (DFG), and other agencies.

The University of Toronto at Scarborough (UTSC) has been undergoing significant enrolment growth, and in addition to the expansion of undergraduate programs, plans are under way to establish new graduate programs on the campus. The campus is also undertaking concerted efforts to support and promote the excellence of faculty research and to maintain and build up areas of programmatic and research strength. As Vice-Principal (Academic) and Dean, Ragnar Buchweitz will provide intellectual leadership for the campus at this pivotal point in its history, help shape its academic vision, provide inspiration to the faculty, lead the development of undergraduate and graduate programs, and work with the Principals and Deans group in continuing to build the tri-campus model.

From the June 2004 announcement of R.-O. Buchweitz's appointment as Vice-Principal (Academic) and Dean at UTSC.

### LISA JEFFREY

Professor Lisa Jeffrey has been recognized again for her outstanding work in mathematics. This spring she won a *Stacie Fellowship*. The Stacie Fellowships were established in memory of Dr. E. W. R. Steacie, President of the *National Research Council of Canada* (NRC) from 1952 to

1962. NRC preceded NSERC, the *Natural Sciences and Engineering Research Council of Canada*, which is now responsible for the funding and administration of selected research at Canadian universities. The Steacie Fellowship is one of the most prestigious awards made by NSERC. It is given for a two-year period.

### BÁLINT VIRÁG

Our department is proud that in the spring of 2004, Bálint Virág received an extraordinarily competitive award, an *Alfred P. Sloan Research Fellowship*. This is a clear indication of the high esteem in which Bálint's past accomplishments and future potential are held by the mathematical community.

### JAMES G. ARTHUR

We are delighted to announce that Professor Jim Arthur is one of the five winners of the prestigious *Killam Memorial Prize* for 2004 in the amount of \$100,000. Carol Bream, director of the Killam program and acting director of the arts division at the Canada Council for the Arts, in her citation, called Jim an "absolutely phenomenal researcher". This award is given by the Canada Council to distinguished Canadian scholars who have established an outstanding reputation in their area of research. It recognizes exceptional career achievements in engineering, the natural sciences, the health sciences, the social sciences, and the humanities.

This is one more well-deserved recognition for Jim. As we all know, one of the latest honours is his election as *President of the American Mathematical Society*.

### EDWARD BIERSTONE AND PIERRE MILMAN

In the summer of 2004, the Canadian Mathematical Society (CMS) announced Ed Bierstone and Pierre Milman to be the winners of the 2005 *Jeffery-Williams Prize*. This prize was established in 1968 by the Canadian Mathematical Society to recognize mathematicians who have made outstanding contributions to mathematical research. Ed and Pierre will be receiving the prize at the CMS Summer Meeting in Waterloo in June, 2005. They will present the *Jeffery-Williams Prize Lecture* at that meeting.

Ed Bierstone and Pierre Milman are honoured jointly for their highly significant work in the study of analytic and geometric properties of singular spaces. Together, they found an amazingly short and ingenious proof of Hironaka's theorem on the resolution of singularities, transforming that result from a monument to be admired to a tool to be used, bringing a new dimension of understanding and accessibility to the resolution process, at the same time extending it, and its applications, to a considerably wider range of spaces.

Jointly with Wieslaw Pawlucki, they achieved as well important progress on the classical open problem posed by

Whitney about differentiable extensions of functions from subsets to the ambient space.

Ed Bierstone and Pierre Milman have also made crucial contributions to the geometry of sub- and semi-analytic sets, exploring their relationship to differentiable functions. Their methods are expected to continue to reveal new and significant features of singular spaces.

From the prize announcement of March 2004 by the CMS

## The James Arthur Conference



James Arthur

Professor James Arthur is regarded as one of the leading mathematicians in the world in the fields of *representation theory*, *automorphic forms*, and the *Langlands program*. He has been a member of the University of Toronto Mathematics Department for many years.

From October 13 to 16, 2004, a conference on automorphic forms and the trace formula was held in honour of James Arthur on

the occasion of his 60th birthday.

The Fields Institute hosted the conference. Nineteen prominent international researchers each gave an hour-long lecture reporting on significant progress in the field.

The conference attracted over one hundred registered participants, from North America, Europe, Israel, and Japan, including more than thirty graduate students and many postdoctoral fellows, as well as several of Jim Arthur's former graduate students.

Robert Kottwitz opened the conference with a talk describing Arthur's extensive contributions, stressing his work on the trace formula. The trace formula is a powerful tool and one of the main techniques in attacking Langlands' Functoriality Conjecture and related problems in the Langlands program, which was started by Langlands' visionary ideas in the late 1960s, and has led to a number of conjectures relating different aspects of automorphic forms, number theory, analysis, and geometry.

James Arthur has almost single-handedly developed the very powerful machinery of the trace formula since the beginning of his career in the early 1970s. His contribution to the modern theory of automorphic forms may be considered as one of the most important. Recent years have



seen exciting and real progress on different aspects of the Langlands program. Many speakers reported on this progress. The trace formula approach was emphasized in a number of talks.

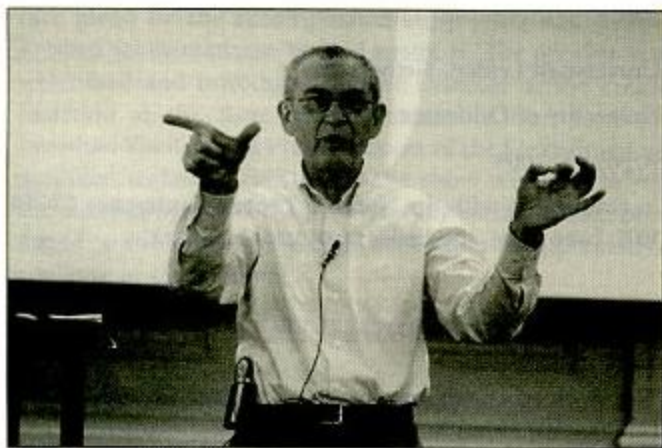
At the end of the first day, the conference participants attended a reception, sponsored by the University of Toronto Mathematics Department, at Hart House.

The conference reception and the banquet were held at the Faculty Club on the evening of the third day of the conference. Everyone at the banquet enjoyed Steve Gelbart's display of slides featuring Jim and his wife Penny, dating back to the 1970s. Several people took the opportunity to make comments, perhaps recalling the circumstances of their first meeting with Jim, or telling a story involving Jim.

The conference organizers were Laurent Clozel, University of Paris-South, David Ellwood, Clay Mathematics Institute, Robert Kottwitz, University of Chicago, Fiona Murnaghan, University of Toronto, and Freydoon Shahidi, Purdue University. Funding for the conference was provided by the Clay Mathematics Institute, the Fields Institute, the MSRI-network conference fund, the U.S. National Science Foundation, and the University of Toronto Mathematics Department, Faculty of Arts and Science, and Connaught Committee.

E. M.

## The Blyth Lectures — Yuri Manin



Yuri Manin

The Eleventh Annual R. A. Blyth Lectures in Mathematics were given this year by Professor Yuri I. Manin. They were held at the Department of Mathematics of the University of Toronto on October 27th, 28th, and 29th, 2004. The first one, a public lecture, focused on:

"The Quantum Computing Project".

The motivation for studying quantum computing arises from several branches of science: physics, cognitive science, and mathematics. Nowadays, there are highly speculative but intriguing conjectures that the human brain acts as (in fact is) a quantum computer. These speculations are motivated, for instance, by the study of the process of writing an efficient chess playing software. It is known that using a classical elaboration of simulating the world championship level, one would need to analyze about  $10^9$  positions/sec and use  $10^{10}$  memory bytes. Since the characteristic time of neuronal processing is about  $10^{-3}$  sec, it is very difficult to explain, if we do not admit the possibility that the human brain acts somehow in a quantum mode, how the world chess winners are so successful in playing that game.

Quantum computing can be briefly described as a process of performing simultaneously several operations (algorithms), instead of processing them separately. Quantum computers are expected to eventually replace the "classical" models, based upon classical processes of computations. Up to the nineties, the basic mathematical models of computing, Turing machines, were classical objects, but the first suggestions for studying quantum models date back at least to 1980. In physics, the quantum mode of description is regarded as more fundamental than the classical one and because of the so-called "superposition principle", it is known that it is computationally unfeasible to simulate quantum processes on classical computers. Quantizing a classical system with  $N$  states produces a quantum system whose state space has a volume growing exponentially with  $N$ . Therefore, the quantum behavior of a system is expected to be much more complex than its classical simulation. The first difficulty one must overcome is the choice of the correct balance between the mathematical and the physical principles.

In his talk, Yuri Manin explained several basic ideas and algorithms of quantum information processing, starting off with a brief report on the classical theory of computability and then proceeding into the discussion of the first attempts to engineer the hardware for quantum computing.

Yuri Ivanovich MANIN was born and educated in Russia. He studied mathematics and physics in Moscow and worked as Professor of Algebra at Moscow University for twenty-six years, directing the research of many young mathematicians. In 1992 – 1993 he held a Professorship at the Department of Mathematics of MIT and, in 1993, he became a Member of the *Max-Planck Institut für Mathematik* in Bonn (Germany) and then, in 1995, a Director of that Institution, holding this position until 2001. Since 2002 he has been a *Board of Trustees Professor* at Northwestern University.

Manin has published numerous mathematical papers covering many fundamental aspects of pure mathematics, logic, and mathematical physics, and also several books on diverse topics in mathematics. Professor Manin is a mem-

ber of the *American Academy of Arts and Sciences* and a member of the *Russian Academy of Sciences*. He is a recipient of the *Lenin Prize* and the *Brouwer Gold Medal*.

Yuri Manin has been a towering figure in mathematics for the last four decades. His work extends from the most abstract field of arithmetic geometry and number theory to the most practical, dealing with the establishment of secure mathematical foundations for present-day physical theories, explaining the structure of matter and the universe.

K. C.

---

## The Graduate School Theses and Awards

We are proud to have attracted excellent graduate students over the years. Each fall we start with about eighty to ninety graduate students who stay with us for a number of years. Many of them finish their graduate studies successfully with a Master of Science degree (M.Sc.). The list of Ph.D. students below speaks for itself. Most of them were able to continue their mathematical research by receiving Postdoctoral Fellowships afterwards, from universities in Canada, USA, Europe, and Asia.

### Ph.D. RECIPIENTS 2004

- AHMAD, Najma — Supervisor: Robert McCann (Applied Mathematics) — Thesis: The Geometry of Shape Recognition via the Monge-Kantorovich Optimal Transportation Problem (in conjunction with Brown University)
- BRANKER, Maritza — Supervisor: Thomas Bloom (Complex Analysis) — Thesis: Weighted Approximation in  $\mathbb{R}^n$
- CHEN, Oliver — Supervisor: Claudio Albanese (Mathematical Finance) — Thesis: Credit Barrier Models
- ESCOBAR-ANEL, Marcos — Supervisor: Luis Seco (PDE, Mathematical Finance) — Thesis: Mathematical Treatment of Commodity Markets
- HUNG, Ching-Nam — Supervisor: Man-Duen Choi (Operator Theory) — Thesis: The Numerical Range and the Core of Hilbert-Space Operators
- IVANESCU, Cristian — Supervisor: George A. Elliott (Operator Algebras) — Thesis: On the classification of simple  $C^*$ -algebras which are inductive limits of continuous-trace  $C^*$ -algebras with spectrum the closed interval  $[0,1]$
- KIRITCHENKO, Valentina — Supervisor: Mikhail Kapranov and Askold Khovanskii (Analytic Geometry) — Thesis: A Gauss-Bonnet Theorem, Chern Classes and an Adjunction Formula for Reductive Groups

KUZNETSOV, Alexey — Supervisor: Claudio Albanese (Mathematical Finance) — Thesis: Solvable Markov Processes

LAWI, Stèphan — Supervisor: Claudio Albanese (Mathematical Finance) — Thesis: Exactly Solvable Stochastic Integrals and q-Deformed Processes

SAVU, Anamaria — Supervisor: Jeremy Quastel (Probability) — Thesis: Hydrodynamic Scaling Limit of Continuum Solid on Solid Model

SHAHBAZI, Zohreh — Supervisor: Eckhard Meinrenken (Differential Geometry) — Thesis: Differential Geometry of Relative Gerbes

SONG, Joon-Hyeok — Supervisor: Lisa Jeffrey (Symplectic Geometry) — Thesis: Intersection Numbers in q-Hamiltonian Spaces

TIMORIN, Vladlen — Supervisor: Askold Khovanskii (Analytic Geometry) — Thesis: Rectifiable Pencils of Conics

The Natural Sciences and Engineering Research Council of Canada (NSERC) gives outstanding Canadian Ph.D. students the opportunity to continue their research by awarding them NSERC *Postdoctoral Fellowships*.

The 2004 recipient was Nan-Kuo Ho.

I. B.

---

## Public Lecture — Hendrik W. Lenstra Jr.

Universiteit Leiden, Netherlands

University of California, Berkeley

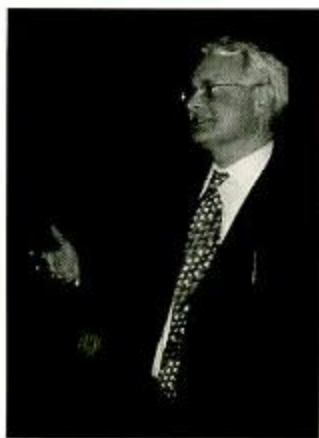
JUNE 22, 2004

In connection with the Number Theory Conference CNTA VIII, June 2004, the Fields Institute, Toronto

### ESCHER AND THE DROSTE EFFECT

The work of Dutch graphic artist *Maurits Cornelis Escher* (1898 – 1972) has intrigued art lovers and mathematicians alike. His work employs symmetries and patterns, and occasionally illusions. Some of it reflects an intuitive discovery and illustration of established mathematical concepts, such as tilings, hyperbolic geometry, the Möbius strip, and conformal mappings. In 2002, a museum devoted to Escher's work opened in The Hague, Netherlands.

Printed on a Droste cocoa box is a picture of a woman



Hendrik W. Lenstra Jr.

holding a Droste cocoa box with the same picture on it. Printed on this smaller Droste cocoa box appears, of course, the same picture, the woman holding a Droste cocoa box, again smaller than before — and so it goes on forever. This process is called the *Droste effect* and lends itself to an impressive computer animation.

Escher's lithograph 'Prententoonstelling' or 'Print Gallery' (1956)

includes a Droste effect. A person standing in a print gallery looks at a print that contains himself, so he sees himself, smaller and standing in a print gallery. This lithograph reveals some far more interesting aspects. A mathematical analysis shows that Escher's drawing is closely connected with a conformal mapping. The whole picture is reproduced again and again, each iteration preserving angles but rotated and reduced in size. Escher accomplished this by drawing part of the picture on a grid and then transforming the grid. The mathematical analysis of the conformal mapping and a resulting computer animation are fascinating. The analysis makes it possible to extend the drawing consistently into the middle of the picture which was left blank in Escher's original. More details are given by B. de Smit and H. W. Lenstra Jr. in their article 'Artful Mathematics: The Heritage of M. C. Escher', *Notices of the AMS*, Vol. 50 (4) (2003), 446 – 451.

All of this and more was brilliantly presented to an enthusiastic capacity crowd of about 256, in a public lecture given by the accomplished story-teller and distinguished mathematician H. W. Lenstra Jr. The speaker was welcomed and introduced by the Director of the Fields Institute at the time, Ken Davidson. Alison Conway, Jonathan Kassian, and Philip Spencer of the Fields Institute provided technical assistance. The show went on: When the main projector broke down, they miraculously produced a substitute in record time, to the appreciative applause of the audience.

E. W. E.

This article was originally published in *Fields Notes*, Fields Institute, September 2004, Volume 5:1.

## Deaths in the Department

E. Prugovecki (1937—2003)

Eduard Prugovecki died on October 13, 2003, in Lake Cha-

pala, Mexico, a place that he loved from previous visits and to which he had moved with his wife Margaret after his retirement in 1997.

Eduard was a member of the Department of Mathematics at the University of Toronto from 1967 to 1997. He joined the Department as an Assistant Professor and became Full Professor in 1975.

Eduard Prugovecki was a highly respected applied mathematician. He had a deep interest in the foundations of quantum mechanics and was working towards finding a mathematically rigorous framework for theoretical physics, capable of unifying various disciplines, aiming for a consistent unification of quantum theory and general relativity. Eduard published more than ninety research papers in quantum physics, in addition to four monographs: *Quantum Mechanics in Hilbert Space* (Academic Press, New York 1971; 2nd edition 1981); *Stochastic Quantum Mechanics and Quantum Spacetime* (Reidel, Dordrecht 1984; revised printing 1986); *Quantum Geometry* (Kluwer, Dordrecht 1992); *Principles of Quantum General Relativity* (World Scientific, Singapore and London 1995).

During the thirty years Eduard spent at the University of Toronto, he taught a wide variety of courses and supervised a number of Ph.D. students and postdoctoral fellows.

Eduard Prugovecki was born in 1937 in Romania. In 1951, he moved with his parents to his father's homeland, Croatia, where he later studied at the University of Zagreb and earned his Diploma in Physics in 1959. He did graduate studies at Princeton University, where he received his Ph.D. in 1965 with a thesis on the empirical and mathematical foundations of quantum mechanics. His supervisors were the distinguished physicists V. Bargmann and A. S. Wightman. He then spent two years at the University of Alberta in Edmonton before he joined the Mathematics Department in Toronto.

Eduard was very much concerned with social issues, and his deep interest in science was accompanied by a sincere awareness of the responsibility of scientists for the positive development of our society, today and in the future. He became drawn to futuristic writing early in his life and, after retirement, published two futuristic novels.

P. R.

J. H. H. Chalk (1922 – 2004)

John Henry Holloway Chalk died on June 28, 2004, in Vancouver, B.C. He joined the Department of Mathematics at the University of Toronto on July 1, 1960. Already at that time, John was a well-established researcher with many papers to his credit.

In 1964, John was instrumental in bringing two other number theorists, Hans A. Heilbronn and Robert A. Smith, into the department, thus creating a very creative and active nucleus in Number Theory. John Chalk, Bob Smith, and Hans Heilbronn were all three interested in exponential sums. There is a conjecture of John Chalk on exponential sums which is still alive. In 2001, T. Cochrane and Zh.

Zheng published a paper "On the upper bounds of Chalk and Hua for exponential sums", and several articles on 'Chalk's conjecture' appeared in the 1990s.

John Chalk's research career spanned some fifty years and resulted in more than fifty publications, appearing in journals of excellent reputation. He achieved results in a wide range of central topics within Number Theory.

Robert Vaughan sheds some light on John Chalk's depth and attitude towards research when he writes in a recent letter, "I remember him describing to me various ways in which things might be taken quite a bit further, and with fundamental consequences. In fact, even now it suggests several things to me which really need to be investigated."

John Chalk's career as a research mathematician had an auspicious beginning. He earned two Ph.D. degrees, one from UC London and one from Cambridge, and he was a Postdoctoral Fellow at Princeton. His supervisors were three of the most outstanding researchers in their fields: H. Davenport, L. J. Mordell, and E. Artin.

During his tenure in Toronto, John received distinguished awards, among them a Canada-France Scientific Exchange Fellowship and a D.S.I.R. Fellowship from the United Kingdom (which he used to spend several months in Nottingham visiting David Burgess to discuss the estimation of character sums). The fellowships enabled John further to go on extended visits at the Faculté des Sciences in Paris, Imperial College in London, and several other universities in Britain and France. He was no stranger at the famous Forschungsinstitut at Oberwolfach in Germany. John was awarded a D.Sc. from London in 1987 and an Sc.D. in 1988 from Cambridge. He was a long-time member of the London Mathematical Society.

John served the Canadian mathematical community in various ways. Prior to accepting the position at the University of Toronto, he spent three years with the Mathematics Department at McMaster University in Hamilton. For several years, he was the Editor of the *Canadian Journal of Mathematics*. John Chalk was well known and internationally respected for his work. This resulted, in particular, in his election as a Fellow of the Royal Society of Canada in 1973.

John Chalk was a very pleasant colleague, reserved and elegant. He was also an excellent lecturer and teacher. His clear and accurate notes were much appreciated by his students. He supervised six Ph.D. students. Their theses eventually resulted in a dozen publications in scientific journals. Robert Vaughan, of the University of Pennsylvania, now a prominent analytic number theorist, was inspired to go into research in number theory after he took his first course on the subject from John Chalk at University College, London, where John spent a sabbatical. Colleagues and students alike appreciated John's quiet ways, his genuine interest in their work, and his fine sense of humour.

William Chen, now Professor of Mathematics at Macquarie University in Sydney, Australia, reminisces as follows about his time at Imperial College in London:

"We used to spend a lot of time at the various pubs talk-

ing about mathematics, cricket, and other things. Bob Vaughan, Klaus Roth, and I regularly shared our number theory notes. Since the notes had been modified so many times, we never quite worked out who had the first version. The only thing we were sure of was that I took my first course from Bob and he took his first from John, so John must have had a lot of influence in the presentation. One day we told John that we both in some sense first learned our number theory from his notes. John was immediate in his reply. No, he had not bothered to prepare any notes — since he had a copy of Davenport's!"

John remained an active member of the mathematical community until long after his retirement from the University of Toronto in 1988. For about ten years he was an Imperial College Senior Fellow in London, lecturing and attending lectures regularly in Cambridge and London. He spent six months in Vienna at the Technische Universität with Peter Gruber and gave several lectures in French at the University of Caens while visiting Yves Hellegouarche.

John H. H. Chalk was born on September 13, 1922, near London, England, where he grew up and received most of his formal education. He spent the last few years of his life in Vancouver, B.C. He leaves his wife, Geraldine, and two sons and their families. They will take John's ashes to England to the Malvern Hills, near Worcester, in the West Country, where his mother came from and where she, too, is buried.

E. W. E., with contributions from Geraldine Chalk, David Burgess, William Chen, John Friedlander, Dipak Sen, Robert Vaughan

#### D. Khmelev (1976 – 2004)

It is with great sadness that I pass on the news that Dmitry Khmelev died on October 24, 2004, in Austin, Texas, suddenly and unexpectedly, from a heart problem.

Dima was a Postdoctoral Fellow in our department from 2002 to 2004, and had just started in the fall of 2004 at the University of Texas as a Bing Instructor. His main work was in dynamical systems, but he also made contributions in probability, as well as computational text analysis.

He was born in Russia in 1976. He obtained his diploma degree in Mathematics from the Faculty of Mechanics and Mathematics at Lomonosov Moscow State University. He also graduated from Physics and Mathematics School #18, founded by Kolmogorov in 1963. Dima obtained a Kandidat degree from Moscow State University in 2001. He spent some time at the Isaac Newton Institute in Britain and was awarded his Ph.D. degree by Herriott-Watt University in 2002 under the direction of Kostantin Khanin.

J.Q.

---