

CMS

NOTES

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## **Robert Langlands, An Explorer of the Abstract**

Interview by Stephane Durand, CRM

*This interview with Robert Langlands originally appeared in Math 2000, a special issue of Québec Science prepared by Mr. Durand for the CRM. It was conducted in French.*

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*How do you choose your subjects of research?*

I like important theories, especially in mathematics and related subjects. I have been taken with some of them, but without really understanding their extent, ever since my student days. I keep coming back to them, one or another, trying to approach them with a little help from calculations. Sometimes, but rarely, these calculations lead me to new and useful ideas.

*What fascinates you most in mathematics: the abstraction, underlying structures, surprising results, rigor...?*

It is not the rigor. That is something which asserts itself. Rigorous proofs are given because they are necessary. What I like is the romantic side of mathematics. There are problems, even some great ones, which no one knows how to approach. One tries to find, then, a path that leads to the summit or even allows an approach to it. There is a comparison that I like very much. Among my heroes is the

Chevalier de la Salle whose ambition was to conquer a whole continent. He had plans for exploration but no one listened to him. Nevertheless he made important discoveries. I like the feeling of being before a virgin continent. I like problems the solutions of which require original and unsuspected theories. In other words, I like mathematics which stimulates the imagination. But I like also the need for simple calculations or manipulation of formulas when theory is lacking.

*Do you believe that mathematics allows going beyond imagination or intuition?*

In mathematics new ideas are created in proportion to its progress. These ideas influence our way of thinking and enable our imagination and intuition to grasp many things which elude naive imagination and intuition.

*How did you come to chose a career in mathematics? Was this choice imposed upon you while very young?*

It was a surprise for me to do mathematics! When I was young, I lived in a small village and worked with my father, who was a carpenter and cabinet maker. I tried to follow this trade and normally I would also have become a carpenter, but I was not gifted! So I had to find something else. And I was led by chance to mathematics.

(see *LANGLANDS*—page 12)

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**EDITORIAL**



*Peter Fillmore*

“Think of mathematics as the Latin of modern times”, so advises Robert Fulford in a *National Post* column this past summer. “It’s the international language of vital work. We who know nothing of mathematics are fated to be more spectators than participants at the central dramas of our times.” This is music to our ears, but on reading further we find he is thinking mainly of the world wide web. Fulford tells us something about the 1999 autobiography of the man “who devised it”, Tim Berners-Lee. His parents, mathematicians at Manchester University, worked on the first commercial computer.

Still, such public recognition is gratifying, and may indicate that our collective efforts in this World Mathematical Year to publicize the importance of mathematics are beginning to bear fruit.

Our professional responsibilities extend beyond mathematics, to the well-being of higher education generally. Here again there is cause for satisfaction, in the increased federal support for infrastructure and salaries. There is cause for concern as well, in that these programmes were not created as a result of informed public debate. They emerged from a murkier political process, and we may reflect that gifts of a seemingly wise and beneficent government may as mysteriously be withdrawn.

Why is the role of mathematics so hidden from public view? Here is a

problem for the new century—and the new millenium!

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«Les mathématiques sont le latin des temps modernes», écrivait Robert Fulford dans un article du *National Post* l’été dernier. «C’est la langue internationale des travaux essentiels. Nous qui sommes étrangers aux mathématiques sommes condamnés à assister passivement au déroulement des grandes scènes de notre époque au lieu d’y prendre part.» Voilà qui fait plaisir à entendre, même si l’on se rend compte plus loin que l’auteur songeait surtout au World Wide Web en écrivant ces lignes. Fulford nous apprend un fait intéressant lu dans l’autobiographie publiée en 1999 de Tim Berners-Lee, le père du Web : ses parents, mathématiciens à l’Université de Manchester, ont participé à la conception du premier ordinateur commercial.

Une telle reconnaissance est tout de même agréable, car elle semble indiquer que nos efforts collectifs à promouvoir l’importance de notre discipline en cette année internationale des mathématiques commencent à porter fruit.

Nos responsabilités professionnelles ne se limitent pas aux mathématiques elles-mêmes, mais à l’intérêt général de l’enseignement supérieur. Nous pouvons là aussi nous réjouir, car nous assistons à une augmentation du financement fédéral consacré aux infrastructures et aux salaires. Il y a aussi de quoi s’inquiéter, par contre, car ces programmes n’ont pas été créés à la suite d’un débat public constructif, mais plutôt d’un étrange processus politique. Il n’est pas impossible que ces cadeaux, d’un gouvernement d’apparence avisé et bienfaisant, disparaissent tout aussi mystérieusement qu’ils sont arrivés.

Pourquoi le rôle des mathématiques est-il si méconnu du public? Voilà un problème de classe pour le nouveau siècle... et le nouveau millénaire!

## Mathematics: Frontiers and Perspectives

*This is the title of a remarkable book produced under the auspices of the International Mathematical Union as part of the World Mathematical Year 2000 activities. In this issue of the NOTES we present excerpts from Sir Michael Atiyah's preface to the volume, followed by brief quotations from a number of the essays making up the book.*



*Sir Michael Atiyah*

Hilbert's problems have stood the test of time remarkably well. They vary in character, from the comparatively easy to the almost impossible, but collectively they convey a clear impression of mathematics in 1900. A list of such problems can provide a useful focus: some problems open doors, some problems close doors, and some remain curiosities, but all sharpen our wits and act as a challenge and a test of our ingenuity and techniques. As Gowers says in his article, solving problems can be either the road to understanding or the purpose of understanding.

In fact, the influence of Hilbert's problems on 20th century mathematics can be exaggerated. Certainly Hilbert captured the headlines (or at least he would have done if headline capturing had been as advanced an art as it now is), but it was Hilbert's own mathematical work that had much more influence. At the risk of oversimplification, one could say that Hilbert's formal approach dominated mathematics for the first half of the 20th century, with Bourbaki as his most famous disciple. The focus on axiomatics and the in-depth development of specific areas was, for a while, remarkably successful. This was followed by a period of hybridisation, where specialities were put together (e.g., algebraic topology

or topological groups). Eventually, the latter part of the 20th century saw a return to a less constrained view of mathematics, more in the spirit of Poincaré (as expounded by Arnold), with its emphasis on geometrical thinking, even in areas such as algebra or number theory. It is worth noting that topology does not figure among the list of Hilbert's problems, but Poincaré, in his address to the 1908 Congress, highlighted it (or *analysis situs* as it was then called) as an important area for the future.

It was widely recognised that no single person could now hope to emulate Hilbert by producing a corresponding list of problems. This is not just undue modesty on the part of contemporary mathematicians. It is more a sober reflection on the enormous range and diversity of mathematics in the year 2000. This volume is therefore a collective effort, but the result is not simply a longer list of problems. Different mathematicians have responded in different ways to the challenge. Some have tried to follow the Hilbert paradigm, but restricted themselves to covering a smaller area (e.g., Jones, Smale, Yau). Others write more from a personal or philosophical viewpoint (Kirwan, Manin, Ruelle) or review likely developments in certain areas (Baker-Wusholtz, Donaldson, McDuff, Wiles). Some concentrate on more detailed problems in depth (Connes, Kazhdan, Mazur), and it is noteworthy that Connes reformulates the Riemann Hypothesis (one of Hilbert's problems) with the full machinery of 20th century mathematics.

In addition to many articles on theoretical physics, there are a few on other important areas of applied mathematics (Lax, Lions, Majda), which stress the interplay between computation, numerical analysis, and partial differential equations, while computational complexity is briefly touched on by Smale. Obviously this does not do justice to the full range of applications of mathematics now and in the future. Probability, for example, is not covered; neither is the key link between logic and computing. It would not be a rash prediction to forecast that real-world problems (including those arising from the continuing computer revolution) will have a profound impact on the development of mathematics in the next century. The basis of such a prediction is as much sociological as scientific, for reasons that I shall try to explain.

Mathematics is affected, not only by other sciences, but also by changes in society. The idea that science, including mathematics, is a "social construct" has gained much notoriety and can be pernicious, but it contains a grain of truth. A cursory look at history and geography will show that the kind of science we do, the way we do it, and the speed and scale of scientific advance are certainly affected by the society in which we live. We need freedom to think and exchange ideas without fear of the Inquisition or its modern equivalents. We

need education and books to learn about our heritage, we need wealth to support us, and we need a rich intellectual environment if we are to achieve our full potential. In return, we must make our contribution to society—to its culture, its science, and its economy. Tangible benefits will be expected.

The 20th century has seen enormous political and social change (not all beneficial). One outcome is a vast increase in those provided with mathematical opportunity. Technology has provided us with instant world-wide communication, and economic prosperity has enabled thousands of mathematicians to make a livelihood. Perhaps the Newtons, Gausses and Ramanujans have not increased in proportion, but other factors make up for this. The 20th century has transformed mathematics from a cottage industry run by a few semi-amateurs into a world-wide industry run by an army of professionals.

The 21st century will almost certainly transform mathematics as a human activity yet again. When China produces mathematicians on a scale proportional to its population and when electronic communication has reached maturity, the scene will barely be recognisable. For centuries, physics has had a close symbiotic relationship with mathematics, and Witten's forecast is that the 21st century will see this rise to new heights. But what of the future of biology? Many predict that understanding the brain will be the major challenge of the next century and, while it would be presumptuous of mathematicians to claim that they will solve the problem, it is not unreasonable to think that mathematics may have a useful part to play. There are also emerging mathematical problems in the handling of the vast data bank produced by the Human Genome Project.

As we look at all the changes that have taken place in mathematics during our lifetime, and the greater changes that are to come, one might become pessimistic: can mathematics continue at this ever-increasing rate and still remain the subject we love? I personally remain optimistic and there are two objective reasons for this optimism. The first is the long history and continuity of the subject. If Newton, Gauss, or even Archimedes were to return, I believe that, after a short course to learn the new jargon, they would understand and even approve of the progress that has been made (though Gauss might say that he had some unpublished papers in his drawer ...). The second reason for optimism is that mathematics has shown a consistent ability to renew itself by a synthesis of preceding work and an infusion of new ideas, some of which originate in the real world. Only in this way is it possible for young mathematicians to keep pushing ahead. This process of rejuvenation and evolution is the theme that concludes Manin's contribution.

In addition to listing his famous problems, Hilbert, in his 1900 address, also indulged in philosophical remarks on mathematics, remarks which are still relevant a century later and not dissimilar to the views I have tried to express as a distillation of the articles in this volume. His words speak for

themselves, and the final passage of his address is reproduced below (from "Mathematical Problems," *Bull. Amer. Math. Soc.*, **8** (1902), pp. 478–479).

The problems mentioned are merely samples of problems, yet they will suffice to show how rich, how manifold and how extensive the mathematical science of to-day is, and the question is urged upon us whether mathematics is doomed to the fate of those other sciences that have split up into separate branches, whose representatives scarcely understand one another and whose connection becomes ever more loose. I do not believe this nor wish it. Mathematical science is in my opinion an indivisible whole, an organism whose vitality is conditioned upon the connection of its parts. For with all the variety of mathematical knowledge, we are still clearly conscious of the similarity of the logical devices, the *relationship* of the *ideas* in mathematics as a whole and the numerous analogies in its different departments. We also notice that, the farther a mathematical theory is developed, the more harmoniously and uniformly does its construction proceed, and unsuspected relations are disclosed between hitherto separate branches of the science. So it happens that, with the extension of mathematics, its organic character is not lost but only manifests itself the more clearly.

But, we ask, with the extension of mathematical knowledge will it not finally become impossible for the single investigator to embrace all departments of this knowledge? In answer let me point out how thoroughly it is ingrained in mathematical science that every real advance goes hand in hand with the invention of sharper tools and simpler methods which at the same time assist in understanding earlier theories and cast aside older more complicated developments. It is therefore possible for the individual investigator, when he makes these sharper tools and simpler methods his own, to find his way more easily in the various branches of mathematics than is possible in any other science.

The organic unity of mathematics is inherent in the nature of this science, for mathematics is the foundation of all exact knowledge of natural phenomena. That it may completely fulfil this high mission, may the new century bring it gifted masters and many zealous and enthusiastic disciples.

Another great mathematician, from the generation succeeding Hilbert, was John von Neumann. His interests cov-

ered a very wide range of pure and applied mathematics, and he had a deep appreciation of the links between them. Perhaps I can do no better than end by quoting from his article on "The Mathematician" (from *The Works of the Mind*, edited by Robert B. Heywood, University of Chicago Press, 1947).

I think that it is a relatively good approximation to truth – which is much too complicated to allow anything but approximations – that mathematical ideas originate in empirics, although the genealogy is sometimes long and obscure. But once they are so conceived, the subject begins to live a peculiar life of its own and is better compared to a creative one, governed by almost entirely aesthetic motivations, than to anything else and, in particular, to an empirical science. ... But there is a grave danger that the subject will develop along the line of least resistance, that the stream, so far from its source, will separate into a multitude of insignificant branches, and that the discipline will become a disorganised mass of details and complexities. In other words, at a great distance from its empirical source, or after much "abstract" inbreeding, a mathematical subject is in danger of degeneration. At the inception the style is usually classical; when it shows signs of becoming baroque, then the danger signal is up.

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According to my first teacher, Gustave Choquet, one does, by openly facing a well known unsolved problem, run the risk of being remembered more by one's failure than anything else.

–Alain Connes (page 35)

I just move around in the mathematical waters, thinking about things, being curious, interested, talking to people, stirring up ideas; things emerge and I follow them up. Or I see something else I know about, and I try to put them together and things develop. I have practically never started off with any idea of what I'm going to be doing or where it's going to go. I'm interested in mathematics; I talk, I learn, I discuss and then interesting questions simply emerge. I have never

started off with a particular goal, except the goal of understanding mathematics.

–Michael Atiyah, quoted by W.T.Gowers (page 66)

Sometime in my early teens, I started feeling an inner urgency, ups and downs of excitement and frustration, caused by such unlikely occupations as reading Granville's course of calculus edited and published in Russian in 1935 by N.N.Lusin. I found this book in the attic of my friend's apartment. Among other standard stuff, it contained the notorious epsilon-delta definition of continuous function. After struggling with this definition for sometime (it was the hot Crimean summer, and I was sitting under the shadow of a dusty apple tree), I got so angry that I dug a shallow grave for the book between the roots, buried it there, and left in disdain. Rain started in an hour. I ran back to the tree and exhumed the poor thing. Thus I discovered that I loved it, regardless.

–Yu I. Manin (page 153)

[P]robability theory and statistical inference now emerge as better foundations for scientific models, especially those of the process of thinking and as essential ingredients of theoretical mathematics, even the foundations of mathematics itself ...stochastic methods will transform pure and applied mathematics in the beginning of the third millenium....The intellectual world as a whole will come to view logic as a beautiful elegant idealization but to view statistics as the standard way in which we reason and think.

–David Mumford (page 197ff)

Quantum field theory is a very rich field for mathematics .... most of its impact on mathematics has not yet been felt .... there is one rather safe .... prediction about twenty-first century mathematics: trying to come to grips with quantum field theory will be one of the main themes. .... The idea of replacing point particles by strings .... is probably as basic as introducing the complex numbers in mathematics.

–Edward Whitten (page 344ff)

It is safe to predict that computational science, fuelled by new mathematical ideas, will grow in the next century and that computing will be an integral part of many branches of mathematics.

–Peter Lax (page 417)

## FROM THE INSTITUTES

### CRM Theme Year 2000-2001

The year 2000-2001 at the CRM is devoted to the rapidly developing field of mathematical methods in biology and medicine. The application of mathematics contributes to the understanding of natural processes both through mathematical models and their analysis, and through the development and application of mathematical methods of inference.

The year emphasizes both aspects, with workshops covering various applications of nonlinear dynamics in biology and medicine, as well as genomics, and medical imaging.

**Workshop on Nonlinear Dynamics and Biomathematics, October 3-6, 2000.** The state of the art in the application of techniques from nonlinear dynamics to diverse fields of biology (biochemistry, physiology, resources management, medical imaging) will be covered.

**Workshop on Memory, Delays and Multistability, October 12-15, 2000.** This workshop will focus on important current issues in the modeling of neural activity in recurrent circuitry, such as recurrent activity thought to lie at the core of sensory information processing. The emphasis will be on the modeling of such activity in real biological systems.

**Workshop on Mapping and Control of Complex Arrhythmias, October 29 - November 1, 2000.** This workshop will cover the recent advances in computational and analytical techniques and power which have opened new avenues for the understanding and intervention in the prevention of cardiac arrhythmias.

**Workshop on Fractals and Modeling in Structural and Dynamical Analysis, November 11-14, 2000.** Classical problems in materials science (surface characterization, description of branching networks) have been given new impetus by the introduction of fractal concepts. This workshop will cover the latest theoretical developments, their contributions in the biomedical field and future directions of investigations.

**Workshop on Mathematical Methods in Brain Mapping, December 10-11, 2000.** Brain mapping is a rapidly growing research field that tries to understand human brain function and anatomy using 3D images from MRI, fMRI, PET, EEG and MEG using geometry, topology, statistics and random fields. This workshop is intended to bring together mathematicians and statisticians interested in brain mapping, and medical researchers interested in mathematical and statistical methods for the analysis of brain mapping data.

**Courses and Seminars: Techniques in Brain Mapping, December 5-8, 2000.** In preparation for the workshop on brain mapping, four series of introductory lectures will be given, covering the geometry of random fields, methods in functional magnetic resonance imaging and methods for EEG analysis.

**MITACS Biomedical Theme Meeting, November 4-5, 2000**

**Conference in Honour of Adrien Douady.** A conference will be held at the CRM on October 20th-21st to celebrate the 65th birthday of Adrien Douady. Participants include: B. Branner, R. Bott, J. Hubbard, T. Lei, M. Loday, M. Lyubich, B. Mazur, J. Milnor, R. Narasimhan, D. Schlomiuk, J.-C. Yoccoz.

**Grande conférence RCM2.** Geoffrey Hinton, (University College London), Title TBA, October 23rd.

Those wishing to participate in any of the above are invited to write to:

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### Recent CRM Publications:

*Higher Regulators, Algebraic K-Theory, and Zeta Functions of Elliptic Curves*, Spencer J. Bloch, CRM-AMS, 2000.

*SIDE III—Symmetries and Integrability of Difference Equations*, Decio Levi and Orlando Ragnisco, Editors, CRM-AMS, 2000.

*The Arithmetic and Geometry of Algebraic Cycles*, B. Brent Gordon, James D. Lewis, Stefan Müller-Stach, Shuji Saito and Noriko Yui, Editors, CRM-AMS, 2000.

*The Collected papers of Sarvadaman Chowla*, James G. Huard and Kenneth S. Williams, Editors, CRM, 2000.

### Legacy of John Charles Fields Symposium

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



*Alan Baker lecturing on Diophantine analysis at the Fields Symposium*

Sir Michael Atiyah gave the opening lecture of the symposium to a packed J.J.R. MacLeod Auditorium on the University of Toronto campus with over 400 people in attendance. His talk, entitled “Mathematics in the 20th Century” proved to be quite provocative and the topic of much debate throughout the three days. On the evening of the 7th, a panel discussion on the future of mathematics was moderated by Richard Kane and consisted of Jim Arthur, Michael Atiyah, Alan Baker, Richard Borcherds, Tim Gowers, Lisa Jeffrey, Cathleen Morawetz, Stephen Smale and Efim Zelmanov. The

discussion was lively and topics ranged from the amount to which physics would continue to inform mathematics to the degree to which computers will one day be able to "do" mathematics.

On the 8th and 9th, the symposium moved to the Royal Ontario Museum and nearly 300 people were in attendance.

On the evening of the 8th, a banquet was held at Hart House. Sir Michael Atiyah spoke on "Mathematics as Architecture". The banquet was sponsored by the Bank of Montreal, the Bank of Nova Scotia, Bettermarkets.com, the Canadian Imperial Bank of Commerce, Centre de Recherches Mathématiques, McMaster University, Nortel Networks, the Pacific Institute for the Mathematical Sciences, the Royal Bank, Toronto-Dominion Bank, the University of Toronto and the University of Waterloo. The meeting was also sponsored by the Canadian Mathematical Society, the Canadian Applied and Industrial Mathematics Society, the Connaught Foundation, MITACS and the Royal Society of Canada.



*Stephen Smale lecturing on the mathematics of learning at the Fields Symposium*

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

All eleven lectures and the panel discussion were filmed and the Fields Institute intends to make these lectures available both over the Internet and on video.



*Cathleen Morawetz and Fields Director Don Dawson at the Fields Symposium*

The following were the speakers at the symposium, with their titles and abstracts:

**Tom Archibald**

*J.C. Fields: the research ideal in mathematics and in the organization of science*

This talk will present an outline of the life, mathematical work, and scientific organizational activities of John Charles Fields (1863-1932). Fields is chiefly remembered as the founder of the Fields Medals, but the talk will go beyond this to concentrate on the origins of his interest in mathematical research and the formation of his ideas about what was mathematically important; including his work organizing and preparing the Proceedings of the International Mathematical Congress of 1924. Fields was a strong voice for the importance of research both inside the University of Toronto and in Canada more generally. The creation of the medal was the conclusion to a long career in the promotion and execution of scientific research at the local, national, and international levels.

**Sir Michael Atiyah**

*Mathematics in the 20th century*

I will try to identify some of the main themes of the century and describe the difference in outlook at the beginning and at the end of the century. I will avoid technicalities and aim to make the presentation intelligible to all who are interested in mathematics. [Editors' Note: Please see the September issue of the Notes for an account of this talk.]

**Alan Baker**

*Diophantine analysis and transcendence theory: the way forward*

The study of equations in integers lies at the heart of mathematics. Numerous results have been obtained through the centuries to resolve particular instances and many great mathematicians (Fermat, Euler, Gauss, Hilbert...) have contributed

to the field. But it is only in recent times that a general method, based on transcendence theory, has been successfully developed in this context. The lecture will survey the prospects for the future with special emphasis on the abc-conjecture.

### **Richard Borcherds**

#### *Automorphic forms*

Automorphic forms with singularities and their mysterious relationships with several areas of mathematics, such as hyperbolic reflection groups, moduli spaces, moonshine, and elliptic curves will be examined.

### **Alain Connes**

#### *Renormalization and the Riemann-Hilbert Problem*

We describe our joint work with Dirk Kreimer. We first show that perturbative renormalization is a special case of a general mathematical procedure of extraction of finite values based on the Riemann-Hilbert problem associated to an (infinite dimensional) complex Lie group  $G$ . We show that passing from the unrenormalized theory to the renormalized one is exactly the replacement of the loop  $\gamma(d)$  of elements of  $G$  obtained from dimensional regularization by the value  $\gamma_+(D)$  (for  $D = \text{dimension of space-time}$ ) of its Birkhoff decomposition,  $\gamma(d) = \gamma_-^{-1}(d)\gamma_+(d)$ . The original loop  $\gamma(d)$  not only depends upon the parameters of the theory but also on the additional "unit of mass"  $\mu$  required by dimensional analysis. We shall show that the mathematical concepts around the Riemann-Hilbert problem provide very powerful tools to lift the usual concepts of the  $\beta$ -function and renormalization group from the space of coupling constants of the theory to the complex Lie group  $G$ . We also show that the group  $G$  acts on the dimensionless coupling constants of the theory, which gives a direct interpretation of the bare action from the Birkhoff decomposition in the diffeomorphism group.

### **Timothy Gowers**

#### *Combinatorics in the service of mathematics*

There are many problems in mathematics which do not appear to be combinatorial but which on close inspection reveal a combinatorial heart. I shall discuss this phenomenon in general terms and illustrate it with several examples, some related to my own work. I hope to demonstrate that there is still plenty of scope for using so-called elementary methods to make progress in mathematics.

### **Vaughan Jones**

#### *Planar algebras: between dimensions two, three and infinity*

Two-dimensional pictures are an unreasonably effective way of representing three-dimensional objects. Planar algebras are two-dimensional structures which sometimes, for ill-understood reasons, extend to three dimensions. Perhaps even more surprisingly planar algebras arose as the solution to a problem in infinite dimensional linear algebra.

### **Maxim Kontsevich**

#### *Limits of complex structures*

Algebraic geometers usually think about the "limit" of a family of manifolds as about a divisor with normal crossing. Differential geometry suggests a different picture of the limit, with foliation-like structures. I discuss two series of examples. In the case of complex curves one obtains a real version of the Hodge theory for smooth surfaces with foliations. In the case of  $n$ -dimensional Calabi-Yau manifolds the limit can be described in terms of a real  $n$ -dimensional manifold (usually a sphere) endowed with two affine structures with singularities.

### **John Milnor**

#### *Remarks on mathematics and biology*

The challenge of understanding complex systems will surely occupy scientists (and in particular mathematicians) through much of the next century. The most challenging problem of all is that of understanding living organisms. The lecture will try to describe some of the complexities which occur on many different scales, ranging from the molecular level to the level of global ecology.

### **Michael Monastyrsky**

#### *Trends in modern mathematics and the Fields Medal*

The Fields Medal has by now rather a long history. More than sixty years have passed since the first awards in Oslo in 1936. Up to now forty-two mathematicians have received Fields Medals. Analysis of the works of the Fields medallists leads one to follow the main trends in the development of mathematics in the second half of the 20th century. Mathematics is a unique subject, a fact that is not always recognized in everyday research. This becomes clearer, however, on studying the work of great mathematicians. This realization is one by-product resulting from an analysis of the works of the Fields medallists. Although the awards recognized only a small number of achievements, in areas of mathematics often widely separated from each other, many truly wonderful developments arose from these results with the passage of time. For this reason an epsilon-grid over the works of the Fields medallists covers a large part of the mathematics of modern times.

### **Stephen Smale**

#### *The mathematics of theories of learning and intelligence*

Theories of learning are pursued in many academic disciplines such as economics, engineering, psychology, biology, and computer science. Each such discipline has its own culture and language, and this has the effect of isolating these different schools from each other. A sound mathematical foundation could help to break down the corresponding barriers and help to give unity to a theory of learning.

Check the institute's webpage, [www.fields.utoronto.ca](http://www.fields.utoronto.ca), for more information.



## 20th Anniversary IMO Alumni Reunion Banquet

Ravi Vakil, MIT

Because I've had the tremendous good fortune of knowing all the Canadian IMO Teams from the mid-eighties to the mid- to late nineties, a good portion of our (nineteen or) twenty year history, Graham asked me to say a few words about the IMO experience.



*Ravi Vakil at IMO Alumni Banquet*

I think most of us would agree that in the end, above all, our IMO experience was about people. Even when it was about math, it was about people.

Intellectually, the point of the program is to take young people in their formative years, with intellectual potential, and make them realize that the world is a far bigger place than they ever could have imagined. It was an entrée into a vast new set of ideas.

And what ideas they were! Elegant, beautiful ideas; unsuspected connections. From Euclidean geometry to the theory of numbers, from intricate combinatorial patterns to incredibly powerful algebraic structures. And connections, connections, connections.

These ideas were so vast that no one could teach you all of them, or even point them all out to you. No, you had to go and explore them yourself, to read and to ask and most of all to wonder — Why is this true? Why does this look like that? Why in retrospect should that have been a reasonable thing to try? What's behind this pattern? And can I see something fundamental and powerful and beautiful, that no one before me has seen before? In short, the point of the program is less to teach, than to spark.

For me, and I'm sure for many of you, these ideas and this fascinating new world was inextricably intertwined with the people that I met. When I came to the training program, the people ahead of me amazed me. The Team of '85, that would go on to an eleventh place finish in Finland, were like gods. They could demolish tricky problems with devastating insights, and explain why complicated mathematical ideas and constructions were in fact perfectly simple, once you looked at them in the right way. The idea of these six individuals going off to Finland to meet some of the best and brightest the world had to offer was intoxicating. They made me want to return the next year, to see the world as they saw it, to know what they knew. And in such a way, each year has as its heroes those who came before.

Another reason to come back was our peers, those learning with us and from whom we learned so much. Most of us came from schools with good teachers, and interesting people, but where there were few like ourselves. So meeting others was a great revelation, and we didn't want to give that up.

One thing that I learned from all of you is that no single stereotype of the young mathematician really holds; you are an incredibly diverse group. Certainly there are a disproportionate number of musicians, of bridge players, of jugglers. And, perhaps surprising to the public at large, you tend to be far more outgoing than most people, irrepressible even. But above all, you are extremely diverse, and most of all you taught me that it is cool to do math, and more generally it is cool to be different, to think about things, to wonder, to take apart and put back together, to be confused and perplexed, to figure things out.

And here of course I don't just mean the people who made the Team. I mean also that top tier of people, perhaps up to 12 or 15 in a good year, who were all at the highest level. And I mean those others who came through the program briefly for a year, some of whom have become good friends of ours. The point of the Olympiad program, secretly, wasn't to produce the six per year sitting here today. The point was to reach large numbers of people, at different levels, and to spark in them a realization of what is possible, beyond the narrow confines of the high school curriculum.

Here's something the oldtimers from the eighties might be interested to know. Some years have had particular depth, a surprisingly large cohort of people who spurred each other on to greater accomplishments. One spectacular such group is in their early twenties right now, and they've done some remarkable things, and will go on to do more. For example, on a mathematical note, this depth led to an event that's been overdue for some time: a Canadian school this year won

the Putnam Competition, dethroning Harvard. The school was the University of Waterloo, represented by Sabin Cautis, Donny Cheung, and Derek Kisman, all IMO alumni. Two other Canadian schools, UBC and Simon Fraser, placed in the top ten. Sabin and Derek were among the Putnam Fellows, the top five in North America, and another Putnam Fellow, Colin Percival of Simon Fraser, had also taken part in the program. I'm not sure when, if ever, Canada last had three Putnam Fellows in the same year. And it doesn't stop there. This year saw the first Canadian winner of the Elizabeth Lowell Putnam award, Wai Ling Yee, another alumna of the program. And many other Canadians did spectacularly well. Definitely a year for the history books.

Despite this talk of competitive achievement, the Olympiad was in some ways a surprisingly noncompetitive event for Canadians. I can't speak for the first few years, but certainly for the most part the Team was told that it doesn't matter how you do at the IMO; the real achievement is being named to the Team. The Olympiad itself is the prize, and any medal is simply icing on the cake. I know I certainly felt no pressure from the coaches to perform; any pressure came from myself. And it was true: at the IMO, someone on the Team was sure to have a good day, someone else was sure to have a bad day, and at the end of the day it didn't really matter. Perhaps because of this attitude of striving without pressure, the Canadian Team has done remarkably well; taking into account our population, very few countries have a better record.

This brings up another aspect of our collective experience at the IMO: not just of being on a team at the IMO, but of being on the Canadian Team at the IMO. Before competing for Canada at the Olympiad, the Canadian flag was for me an institution, one in which I had passive pride. But after the Olympiad, I could never look at the Canadian flag in the same way again. The experience has made me believe that everyone should travel outside their country, and I mean really travel and meet people, so they can return home and see their country with new eyes. We not only learned about the world by meeting people from every corner of it; we also learned about ourselves.

I was surprised at how often people's eyes would light up when they learned that I was Canadian. I realize now that people's response to Canadians comes in part because of their experience with Canadians, and that in many ways people on the IMO Team really are ambassadors: the people they meet will go back to their home countries, with ideas about Canada shaped by their experiences with the Canadian Team.

Speaking now as a former Deputy Leader, I know that, at least in the nineties, and by all accounts all the way back to '81, the Canadian Team has distinguished itself as one of the most outgoing, funloving, and friendly teams at the IMO. In

some sense, our national identity comes out at events such as these. In each of my five years as Deputy Leader, I was repeatedly complimented by other leaders, deputies and organizers at how wonderful the Canadian Team was. I remember for example the 1993 Team, in Istanbul, where a small contingent of competitors representing Bosnia, a country then experiencing terrible tribulations, was adopted by the Canadians. I remember the Canadians that year giving an impromptu concert in the dining hall, playing, on glasses filled with water, the Blue Danube, in full harmony. And I remember, at the awards ceremony, all of the Canadians, including the adopted Bosnians, receiving ovations from the audience.

So here we are, years after the applause has died down. The vanguard, the '81 Team, is now almost 20 years out. So where are we now? What are we doing? To this year's Team I say: you see sitting with you today, your future; but which future will you choose?

For the IMO alumni were incredibly diverse when they were younger, and they have gone on to use their talents in equally diverse ways professionally. I was curious to see the bios, to see what people have done, and in some ways I'm a little surprised. No one path has predominated. We're in many parts of academia, from pure mathematics and theoretical physics, to medicine and genetics, to computer science. Even more of us are somewhere in the spectrum between the computer industry and the world of high finance.

So what then has the Olympiad given us, if we've travelled these disparate routes? Well, there's the obvious: thinking skills. Early on we learned to struggle with tough, non-standard problems, unlike any we'd seen before. We learned perseverance. And a self-confidence that comes with young achievement, although this can often be dangerous — there is no curse greater than being labelled "promising".

Less obviously, the Olympiad has made us part of a loose intellectual network, with friends in high places in many different fields. It has given us people to whom we can go for advice, and people who come to us for advice. I know in the academic world I've made good use of it, to find out about schools, and what it is a mathematician actually does.

My life has turned out dramatically differently than it would have without the Olympiad, in many, often subtle, ways. And I know that that's true for many of the alumni here as well. So I'd like to end by thanking the people who made it possible. Unlike other countries, in Canada, the Leaders, Deputies, and other workhorses in the Canadian Mathematical Society have worked tirelessly as unpaid volunteers, as a labour of love. This means donating a huge amount of time, on top of a full month out of the year. And that's aside from running the entire 1995 Olympiad!

## IMO 2000 in Seoul

Competing against students from 81 other countries, Canadian high school students have won a gold, two silver and one bronze medal at the 41st International Mathematical Olympiad (IMO), Seoul, Republic of Korea, July 13-25, 2000. David Arthur (Upper Canada College, Toronto) placed seventh in the world out of 461 students.



*Canada's 2000 IMO Team*

The six members of the 2000 Canadian IMO team were: David Arthur (gold), Upper Canada College, Toronto; Daniel

Brox (silver), Sentinel Secondary School, Vancouver; Denise Cheung (honourable mention), Albert Campbell Collegiate Institute, Toronto; Keon Choi (bronze), A.Y. Jackson Secondary School, Toronto; David Goodman, Kelvin High School, Winnipeg; David Pritchard (silver), Woburn Collegiate Institute, Toronto.

Although students compete individually, country rankings are obtained by adding the team's scores. The maximum score for each student is 42 and for a team of six students the maximum is 252. The Canadian team placed 17th out of 82 competing countries with a score of 112.

The top 10 teams and their scores were: China (218), Russia (215), United States (184), Republic of Korea (172), Vietnam (169), Bulgaria (169), Belarus (165), Chinese Taipei (164), Hungary (156), Iran (155).

The 2000 Team Leader was Dr. Andrew Liu (University of Alberta) and the Deputy Team Leader was Dr. Christopher Small (University of Waterloo). Ms. Viktoria Mineva (Alberta International College), was the Deputy Leader Observer.

The 42nd International Mathematical Olympiad will take place in Washington, DC, USA in July 2001.

## UPCOMING CONFERENCES

### Sixth International Conference on Approximation and Optimization in the Caribbean Guatemala City, Guatemala, March 25 - 30, 2001

This conference is the sixth of a series dedicated to research on Approximation and Optimization. The first two meetings were held in Havana in 1987 and 1993. Since then, these meetings have been organized every two years in a country of the Caribbean area: Puebla (Mexico) in 1995, Caracas (Venezuela) 1997, Pointe-à-Pitre (Guadeloupe) 1999.

The goal of these conferences is to support the development of high level research and education in the Caribbean. Included are: invited lectures, tutorials, mini-symposia, and contributed talks on the following topics:

**Approximation:** Wavelets, polynomial and rational approximation, splines, orthogonal polynomials, interpolation, asymptotic analysis, radial basis functions.

**Optimization:** Continuous and discrete optimization, parametric, stochastic and global optimization, nonlinear equations and inequalities, nonsmooth analysis, critical point theory, control theory.

**Mathematical economics:** Fixed point theory, equilibria of competitive economies, portfolio problems, cooperative and non-cooperative games.

**Applications:** Engineering and energy models, robotics, pattern recognition, image restoration, applications in biology, economy and sciences

For more information: [apopt6@usac.edu.gt](mailto:apopt6@usac.edu.gt); <http://www.ing.usac.edu.gt/apopt6/>

(*LANGLANDS—continued from page 1*)

## The Langlands Programme.

The research of Robert Langlands has established an extremely important and fruitful link between two different branches of mathematics: the theory of numbers and certain forms of symmetry. The theory of numbers studies the structures hidden in the behaviour of whole numbers, while a symmetry is an action which leaves an object unchanged. For example, if a quarter turn is given to a square, we obtain an identical square. This apparently very simple idea can become extremely complicated when we apply it to more abstract mathematical objects, and in particular to mathematical structures of infinite dimensions. The Langlands programme, considered today as the key to the vault of number theory, has thrown new light on many old problems. In particular, the proof of Fermat's Last theorem depends on it.

But I was not a serious student in secondary school; I wanted to be a rebel and do nothing. But since I had skipped a year, I was younger than my comrades and so not old enough to be on my own. In my last year of secondary school, one of my teachers, Mr. Vogler, whom I was not successful in finding much later when I wished to thank him, took an hour of class time simply to persuade me to continue. And he did persuade me.

Then I went to University, quite young and not knowing what direction to take. I passed the aptitude tests. Afterwards, the counsellor told me that I seemed to be good in mathematics. He advised me to study to be an actuary, which did not seem to be appealing enough to me, or to become a mathematician, for which he mentioned that a doctorate was necessary. I did not know what a doctorate was and was afraid to ask him. That same day, I asked someone else what this word meant. He explained it to me, and I told myself that I would have a doctorate. That is how my choice of a mathematical career came about! In fact, I believe that that was the first occasion where I encountered something serious. I was simply seized by it.

*It is said very often that mathematicians make their greatest discoveries when they are young. Is this true in your case?*

My most important discovery was made at the age of 31 years. But I started my career a little late. I regret very much not having started at 12 years of age, which would have been possible under other circumstances. Those four or five years

would have been advantageous to me in what followed. But also, perhaps, these adolescent 'frittered-away' years gave me a taste of liberty and independence which a steadier training would have destroyed.

*In physics, the theory of relativity and quantum mechanics have taught us to question ideas which seem natural and not to trust our senses. Are there similar examples in mathematics?*

I trust my senses always, except that with age I have become myopic and a bit deaf, but I understand what you are saying. Relativity and quantum mechanics have turned the ideas of thinkers upside down and have also influenced the thought of people in general. In mathematics, Gödel's Theorem, stating that there exist true but indemonstrable statements, has had a similar effect although somewhat less powerful. Another example is the following: In the sixth century B.C., at the time of Pythagoras, the discovery of irrational lengths was upsetting. Mathematicians and philosophers of the period apparently had a hard time changing their ideas and constructing a geometry which took account of the discovery. Yet another revolutionary discovery is that due to Gauss, Lobachevski and Bolyai at the beginning of the nineteenth century. They proved the existence of geometries for which the Euclidean hypothesis, which asserted the existence of a unique straight line parallel to a given straight line and passing through a given point, is false. This discovery was mistrusted for a long time, but the examples of these great scholars led to Riemannian geometries and finally to Einstein's theory of general relativity.

*Do you have examples of surprising results which defy your intuition and imagination?*

Personally, I find that Fermat's Last Theorem, although now proved, defies my intuition and imagination.

*Yet you contributed to it indirectly!*

Only indirectly, that word is important. Fermat's Theorem is an unexpected consequence of another theorem (of Taniyama-Shimura-Weil). This last belongs to a coherent body of work, which I believe because it corresponds to an order which I am accustomed to in the theory of numbers, and which constitutes for me its beauty. On the other hand, according to my intuition and imagination, Fermat's theorem could be false without disturbing this order.

*What is your vision of mathematics?*

That the word 'mathématiques' is plural in French expresses very well that in mathematics, as in literature and music, there are aspects to satisfy every taste. We have: (1) Current mathematics, even if to my taste a bit light, like combinatorial analysis which is often difficult and very important in contemporary applications, but which requires neither deep mathematical culture nor a wide knowledge of other areas of science; it requires, nevertheless, sharp intelligence, and a part of this field will add, undoubtedly, to mathematical heritage and enrich it. (2) High mathematical culture, rooted in the

classical world, but above all in the eighteenth and nineteenth centuries, and of which the proof of Fermat's Last Theorem is the most well-known success. (3) Mathematics allied to natural sciences. The most important are, perhaps, geometry, fluid mechanics, probability theory with its connections to statistical mechanics, and perhaps the mathematics yet to be established and developed for renormalisation in the theory of particles and statistical mechanics.

*In conclusion, what are the important problems today?*

If I had the strength and the time, and I have neither the one nor the other, there are three problems to which I would

like to contribute: first the notion of functoriality which is central to the Langlands programme, above all, concerning its applications to the important problems of number theory such as Artin's conjecture, Ramanujan's conjecture and the Hasse-Weil conjecture; secondly, an analytic theory of renormalisation which would apply firstly to statistical mechanics, but which would be deep enough to be carried over to the quantum theory of fields of high energy (i.e., physics of elementary particles); and thirdly, an understanding of the mathematics of turbulence. But, alas, at my age, these are just castles in the air!

## Some Ideas for a Good Research Talk

Peter Zvengrowski, University of Calgary

Having just attended the splendid CMS Summer Meeting at McMaster, and gone to many talks in the sessions as well as five plenary talks and the public lecture, I (and I am sure most other delegates) came away with strong impressions about the quality of the various presentations. How well did the speaker communicate their ideas, their research, and with their audience? Certainly most of us want to maximize the quality of our presentation, and it is also clear that this is not always done. Since the plenary talks and the public lecture have to deal with very different problems and a different audience than the half hour research talks, I will only try to pass on a few impressions about the half hour research talks and how these could often be improved. Also, talks in some sessions such as History, or Education, present quite different problems from a talk on mathematical research, and some of what is said below may not apply to such talks.

One thing most of these talks will have in common is that the audience will be highly interested people in the same general area, so the talk can be aimed at specialists. Nevertheless the talk should start with a good introduction, including the historical background, for at least the first 5 minutes. The speaker should be sure that he/she will explain the main concepts and definitions pertaining to their talk and have ample time to state their main results. This is clearly difficult in just half an hour, but there is a pretty good solution to figuring out how one will divide up the time in the best way beforehand: give (inflict?) the talk a few days before the meeting to a friend (with a watch). Once you know that it will fit fairly well into the allotted time, you will be much more relaxed about presenting it at the meeting.

Another interesting question is how to make the best use of available technology to present the talk. The blackboard

has served pretty well since its invention in 1866, but over the past 20 years or so it has been mostly replaced by prepared projections, and these are also regarded as obsolete by proponents of the latest power point + laptop computer presentations (which might also be obsolete in at most three years). Interestingly, at the sessions I attended, by far the best presented talks (two only) used just the blackboard. This was not only my opinion but several people I asked agreed with me. The prepared slides often had the disadvantages of being barely legible, being replaced too fast, and in the worst cases being read verbatim to the audience. In such cases one wonders why not just hand out the material on the slides to the audience and save them the trouble of going to the talk? This is not to say that judicious use of slides or computer technology cannot greatly enhance a talk, or conversely that some people write so poorly on a blackboard that it is more or less illegible. Each speaker should carefully think about the best use of slides or computers to enhance their talk, and usually I would say the minimum use is best. Also if prepared transparencies are being used then the well known AMS suggestions for transparencies should at least be approximately followed.

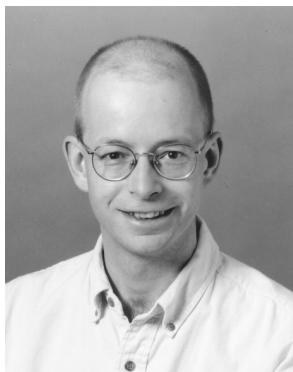
A final small but useful point when transparencies are used is to have a pointer. It beats stretching and blocking most of the slide with one's body, or trying to put one's finger on the transparency and blocking most of it with the hand. The pointer need not be a high-tech laser (which may easily run out of batteries right in the middle of your talk). I have been at meetings where a branch of a tree did the job handsomely (although my personal favourite is an old ski pole where the basket has fallen off).

## RESEARCH NOTES

Noriko Yui and James D. Lewis, Column Editors

### Royal Society of Canada New Fellows

Four mathematicians have been elected to the Academy of Science of the Royal Society of Canada, including Andrew Wiles, who was elected a foreign fellow.



**Nigel Higson**  
Department of Mathematics,  
Pennsylvania State University

Nigel Higson is a leader in the field of operator algebras in Hilbert space, together with its applications to geometry, topology, and the representation theory of groups. He has made definitive contributions towards the solution of deep conjectures due to Novikov, and to Baum and Connes. His work will have lasting influence.

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**John McKay**  
Departments of Computer Science  
and Mathematics, Concordia  
University

John McKay pioneered the field of computational group theory, especially the construction of characters

and new simple groups. He discovered deep connections between group structures that have driven fundamental developments in finite groups over the past three decades, such as the “Alperin-McKay conjecture”, relating irreducible characters of groups and their local subgroups. His discovery of the “McKay-Thompson series”, relating expansions of modular functions to the characters of the “Monster” sporadic group, led to the “Moonshine” conjectures, proved recently by Borchers. He also discovered a deep relationship between certain finite groups and associated Lie algebras, known as the “McKay correspondence”, which has had many recent applications in mathematics and physics.

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**Gordon Slade**  
Department of Mathematics,  
University of British Columbia

Gordon Slade is the world’s leading expert in the use of the lace expansion. With Takashi Hara, he has used this technique to solve a series of difficult and important problems in statistical mechanics. He has proved “mean field” behaviour of the self-avoiding

random walk above the critical dimension of 4, and of percolation in sufficiently high dimensions. Working with his student Eric Derbez, Slade has also connected two quite distinct areas of probability by proving that, above the critical dimension of 8, lattice trees converge to the integrated super-Brownian excursion.

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**Andrew J. Wiles**  
Department of Mathematics,  
Princeton University

Andrew Wiles has, through his insight and perseverance, made one of the most distinguished contributions to mathematics. In establishing the celebrated Taniyama-Shimura-Weil Conjecture, he, at one and the same time, put to rest Fermat’s Last Theorem, unproved for almost four hundred years, and provided crucial verification – solving the one-dimensional case – of the so-called Langlands program – a remarkably far-reaching conjectural synthesis (by the Canadian mathematician Robert Langlands) of much of the mathematics of that four hundred years – much of which was brought into being by the riddle of Fermat.

## Mathematical Expeditions: Chronicles by the Explorers

Book Review by Tom Archibald, Acadia University

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**Mathematical Expeditions**  
by Reinhard Laubenbacher and  
David Pengelley  
New York: Springer, 1999

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The history of mathematics is enjoying a vogue at present, as it did near the end of the nineteenth century. It would be interesting to know whether it was the case then, as it is now, that an aging mathematical population was looking back at its roots. Whatever the reason, there is a boom in the production of research monographs of high quality, of articles in increasingly professional journals, and in works based on these which synthesize the new literature, often for pedagogical purposes. High demand tends also to see the production of a fair amount of dross, where authors with amateur interests fail to make contact with the existing literature or use historical conceits to grind mathematical or philosophical axes. The last, unfortunate, tendency can be laid squarely at the feet of publishers who fail to enforce exacting standards in the interest of acquiring still more product. The series in which this work appears, while containing some excellent works, has not been immune to this tendency.

Happily the book by Laubenbacher and Pengelley is a fine example of using historical work to put mathematicians and students in touch with important roots of their subject. Selecting five mathematical themes, the authors present a selection of original source documents in English translation, together with historical commentary which provides mathematical and historical background for the passages in question. The themes are all central to our image of pure mathematics: the parallel postulate from Euclid to Poincaré; set theory from Bolzano to Zermelo; analysis beginning with Archimedes and passing via Leibniz and Cauchy to Robinson; Fermat's last

theorem from antiquity to Kummer; and the algebra of equation-solving. All these are standard stories, with which most readers of the *Notes* will have at least a passing acquaintance, if only from reading boxes in textbooks or the imaginative quasi-histories of E. T. Bell. But Laubenbacher and Pengelley do a fine job of bringing these old stories up to date, using historical literature to improve on older anecdotal writings, and the words of the original authors are well-selected, clearly translated, and deeply fascinating at times. In addition, the volume contains the fruits of some of their own researches in these areas, perhaps most notably in the account of Sophie Germain's number-theoretic work.

As an example of how the authors proceed, consider the second chapter, which concerns the development of the theory of sets. They begin with a lively summary of the history of problems with the infinite, mentioning Aristotle and then jumping to Bolzano, dwelling extensively on Cantor, noting Russell's paradox, and concluding with the work of Zermelo. The reader is referred throughout to a combination of mathematical and historical literature, ranging from scholarly biography (Dauben's book on Cantor) to popular works (Maor on  $e$ ) to introductory and advanced mathematical treatises. Then follow more detailed treatments of Bolzano, Cantor, and Zermelo, each accompanied by one or more reading selections from the original. Cantor is represented by around 10 pages of text, with interspersed commentary. Relevant exercises follow which encourage the reader to work from the original text to understand basic ideas. Thus the reader is invited to prove that  $\aleph_0 + \aleph_0 = \aleph_0$  using Cantor's original conceptions and notation, in my view a tremendously valuable exercise for the student, and an instructive one for those used to working with contemporary ap-

proaches to the field. Thus even though the treatment is by no means a complete history, the reader encounters important mathematical issues directly, and receives generally good guidance to further literature on mathematical extensions and historical details.

The book, easily readable for mathematicians and graduate students, is presented as an undergraduate text, and one might ask how well it will address an undergraduate audience. The authors themselves have used this approach as part of a "capstone" course for mathematics majors, that is, a course which comes at the end of a student's undergraduate career. For students who have followed a conventional preparation in pure mathematics this should work well, though naturally some portions of the work will be more accessible than others. The exercises seemed to me at about the right levels of difficulty for upper-year students. Some of the reading selections are certainly very demanding, and will require careful attention both from the instructor and from the students. The authors' commentaries seemed to me very helpful here, for example in unravelling Cantor.

Most mathematicians will be very comfortable with the view of their subject which this work presents. Statements such as "This objection to the parallel postulate [due to Proclus] was shared by mathematicians for the next 2000 years" are a bit awkward (Proclus flourished about 1600 years ago), but also point to the non-historical viewpoint that once something is discovered or created, it is well and truly known, and its mathematical content is temporally unalterable. While the authors would doubtless not agree with this statement, unthinking remarks here and there in the text suggest that this is their fundamental stance. From the historian's viewpoint it is better to adopt

a more critical take on the universality of mathematical truths, and to try to understand what people in different places and times were doing when they did what we now describe as mathematics. History definitely takes the back seat here, as may be seen from Exercise 1.1: "Read about world history from

1750 until 1850", which is not accompanied by any suggestions about *what* one should read.

However, this is not a work intended for apprentice historians. The mathematical parts of the stories are quite enough for a work of this length and depth, and they are told with math-

ematical clarity, accuracy of detail, and verve. I recommend the book as part of the education of any undergraduate, and as a useful corrective to folkloric accounts of many of the subjects it touches. It would make a fine centerpiece for an historically-oriented seminar course.

## AMERICAN MATHEMATICAL SOCIETY

### Conference Proceedings, Canadian Mathematical Society

This series is published for the Canadian Mathematical Society by the AMS. It consists of the proceedings of internationally attended conferences on pure and applied mathematics sponsored by the CMS. CMS members may order at the AMS member prices. (ISSN 0731-1036) Softcover.

**NEW! Constructive, Experimental, and Nonlinear Analysis**  
**Michel Théra, University of Limoges, France, Editor**

This volume presents twenty original refereed papers on different aspects of modern analysis, including analytic and computational number theory, symbolic and numerical computation, theoretical and computational optimization, and recent development in nonsmooth and functional analysis with applications to control theory. These papers originated largely from a conference held in conjunction with a 1999 Doctorate Honoris Causa awarded to Jonathan Borwein at Limoges. As such they reflect the areas in which Dr. Borwein has worked. In addition to providing a snapshot of research in the field of modern analysis, the papers suggest some of the directions this research is following at the beginning of the millennium.

Volume 27, 2000, approximately 302 pages, Softcover, ISBN 0-8218-2167-9, List \$70. Individual member \$42. Order code CMSAMS/27CMS99

**Stochastic Models**  
**Luis G. Gorostiza, Centro de Investigación y de Estudios Avanzados, Mexico City, Mexico, and B. Gail Ivanoff, University of Ottawa, ON, Canada, Editors**

This book presents the refereed proceedings of the International Conference on Stochastic Models held in Ottawa (ON, Canada) in honor of Professor Donald A. Dawson. Contributions to the volume were written by students and colleagues of Professor Dawson, many of whom are eminent researchers in their own right.

A main theme of the book is the development and study of the Dawson-Watanabe "superprocess", a fundamental building block in modelling interacting particle systems undergoing reproduction and movement. The volume also contains an excellent review article by Professor Dawson and a complete list of his work.

This comprehensive work offers a wide assortment of articles on Markov processes, branching processes, mathematical finance, filtering, queueing networks, time series, and statistics.

Volume 26, 2000, 450 pages, Softcover, ISBN 0-8218-1063-4, List \$74. Individual member \$59. Order code CMSAMS/26CMS00

**Geometric Control and Non-holonomic Mechanics**  
**V. Jurdjevic and R. W. Sharpe, University of Toronto, ON, Canada, Editors**

Control theory, a synthesis of geometric theory of differential equations enriched with variational principles and the associated symplectic geometry, emerges as a new mathematical subject of interest to engineers, mathematicians, and physicists. This collection focuses on several distinctive research directions having origins in mechanics and differential geometry, but driven by modern control theory.

The first of these directions deals with the singularities of small balls for problems of sub-Riemannian geometry and provides a

generic classification of singularities for two-dimensional distributions of contact type in a three-dimensional ambient space.

The second direction deals with invariant optimal problems on Lie groups exemplified through the problem of Dubins extended to symmetric spaces, the elastic problem of Kirchhoff and its relation to the heavy top. The results described in the book are explicit and demonstrate convincingly the power of geometric formalism.

The remaining directions deal with the geometric nature of feedback analyzed through the language of fiber bundles, and the connections of geometric control to non-holonomic problems in mechanics, as exemplified through the motions of a sphere on surfaces of revolution.

This book provides quick access to new research directions and also demonstrates the effectiveness of new insights and methods that control theory brings to mechanics and geometry.

Volume 25, 1998, 239 pages, Softcover, ISBN 0-8218-0793-1, List \$49. Individual member \$29. Order code CMSAMS/25CMS00

**Algebras and Modules II**  
**Idun Reiten, Sverre O. Smalø, and Øyvind Solberg, Norwegian University of Science and Technology, Trondheim, Editors**

This volume contains 43 research papers based on results presented at the Eighth International Conference on Representations of Algebras (ICRA VIII) held in Geiranger, Norway. The papers, written by experts in the field, cover the most recent developments in the representation theory of artin algebras and related topics.

Volume 24, 1996, 569 pages, Softcover, ISBN 0-8218-1076-0, List \$90. Individual member \$59. Order code CMSAMS/24CMS00


**Algebras and Modules I**  
**Idun Reiten, Sverre O. Smalø, and Øyvind Solberg, Norwegian University of Science and Technology, Trondheim, Editors**

This volume contains recent results on geometric aspects of representations of algebras, a thorough treatment of the theory of quasifinite algebras, new developments on infinite dimensional representations of finite dimensional algebras, a bridge between representation of algebraic groups and representation theory of finite dimensional algebras, and recent discoveries on modular representation theory. In addition, the volume contains two papers devoted to some of Maurice Auslander's many contributions both in the representation theory of finite dimensional algebras and in commutative ring theory.

A general background in noncommutative algebra including rings, modules and homological algebra is required. Given that, parts of this volume would be suitable as a textbook for an advanced graduate course in algebra.

Volume 23, 1998, 198 pages, Softcover, ISBN 0-8218-0850-6, List \$39. Individual member \$23. Order code CMSAMS/23CMS01

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# AMS

AMERICAN MATHEMATICAL SOCIETY



## EDUCATION NOTES

Ed Barbeau, Column Editor

We are in the middle of a revolution in the design and delivery of mathematics curriculum under adverse demographic and political circumstances. Making sure that there is a qualified corps of teachers in front of our children is the task of the Faculties of Education, many of which are meeting the challenge with imagination and energy. The Faculty at Queen's, in particular, continues its long and distinguished record of leadership, and I have asked Professor Lynda Colgan to describe a new course designed to ameliorate the effects of a large number of new entrants to teaching in the face of a loss of many experienced teachers. While the preamble of her article describes the Ontario situation, the situation in that province is not atypical of that across the country and so the Queen's approach may be of interest to all of us. Professor Colgan can be reached by email at [colganl@educ.queensu.ca](mailto:colganl@educ.queensu.ca).

### Meeting the Challenge: Mentoring and Leadership Training in Pre-Service Teacher Education

**Introduction.** Estimates suggest that of the 171 500 qualified teachers in Ontario, 41 000 will retire within five years and more than 78 000 within 10 years. This means that by 2003, about one in four qualified teachers living in Ontario will retire and about one in two by 2008. Other projections tell us that over the next five years we will lose 9000 principals and vice-principals, 46% of the total currently employed in Ontario.

These data were obtained from the Ontario College of Teachers (OCT), the body that has the responsibility to alert the teaching profession and other education stakeholders to potential teacher shortages that could limit availability of qualified teachers to fill classroom vacancies.

The OCT data ([www.oct.on.ca](http://www.oct.on.ca)) suggest that the elementary and secondary panels will be similarly affected. The projections suggest that every region of the province will be hit, and that while all subject areas will be affected to a significant extent, mathematics, science, computer technology, and technological studies are immediate areas of concern (in fact, a November 1998 Ministry survey found 43 unfilled mathematics positions in midterm across the province). Other trends predict a sharp decline in male teachers at both the elementary and secondary level. Worse still, in mathematics and science in particular, faculties of education have difficulty attracting the number of candidates that they can accommodate. The forecast retirements represent a loss of energy and vitality, as well as some three million years of experience and expertise.

For most of the decade just past, large numbers of graduates from Ontario faculties of education scattered to teaching jobs around the globe or found other occupations; however,

in the last two years, record high numbers of graduates have immediately joined the province's teaching profession. This has polarized the teaching demographic; most have lots of experience, a few have little experience, and there is not much in between. Worse, the Ontario reserve pool of inactive or expatriate teachers has now largely been exhausted. The infusion of new blood brings welcome energy and current perspectives. It also means that huge numbers of beginning teachers need support from an ever-declining group of experienced colleagues as they gain confidence and competence and seek mentoring both to sustain and stretch them.

Disturbing too is the critical shortage of leaders for our schools. Not only do we find ourselves in a position in which 44 per cent of teachers with principal qualifications are eligible to retire within five years and 64 per cent within ten years, not enough qualified people are applying for promotion. Usually a candidate for principal must teach for five years, be qualified in three of the four school levels (Primary, Junior, Intermediate, High School), have specialist qualifications in two subjects or be halfway to a master's degree before they take the two-part Principal Course. However, last year alone, the College of Teachers allowed 110 people to work as vice-principals while they finished their training, up from *three* the year before.

As the need for administrators intensifies, pressure is beginning to build for classroom teachers to fill the void, further straining the almost-dry teacher pool. Worse, unqualified and inexperienced people will administer at a time when social and political pressures are placing increased demands on the role.

**One response.** At the Faculty of Education at Queen's University, Kingston, we are addressing these issues from a number of perspectives. One of the initiatives is a new course designed especially for Associate Teachers called *Mentoring in Pre-Service Teacher Education*. Designed to help teachers who may themselves have limited experience to be able to successfully advise beginning teachers, this course focuses mainly on mentoring within the context of initial teacher education and induction. The course examines a number of key issues: *What is the mentor's role? What are the skills and strategies mentors need to learn? How does this relate to models of teacher learning and notions of the teacher's role such as the development of the reflective practitioner?*

Through readings, assignments and class discussions, associate teachers have an opportunity to increase their personal knowledge of:

- mentoring and the conceptual underpinnings of the mentoring process;
- the role of the mentor in initial teacher education;
- the conflicts and tensions in the mentor role;

- the action research process;
- reflective practice; and
- assessment in the context of mentoring.

Another new focus track course, *Elementary Mathematics Leadership*, will begin in September, 2000. This course provides opportunities for teacher candidates who have a strong mathematics background and a positive disposition towards mathematics to explore the changing face of mathematics in school in order to prepare them to provide leadership to their colleagues and others with an interest in mathematics education. *Elementary Mathematics Leadership* will explore the new curriculum standards and assessment measures within mathematics teaching and learning. The focus of the course is on teacher development and the change process. As members of this focus course, teacher candidates will be required to participate in seminars, lead workshops, work to help teachers implement the new mathematics pedagogy and to spend the winter practicum in a mathematics-focussed environment.

During September, the teacher candidates will be introduced to the focus track by briefly exploring the evolving constructivist understandings of mathematics learning and meet some educators who are meeting the challenge of reconstructing their teaching practice. They will be introduced to the deep and difficult issues involved in making the contemporary 'vision' of mathematics real in classrooms by studying the ideals articulated by leading mathematics educators, and gaining awareness of issues concerning the teaching and learning of elementary mathematics within the public school system.

After a 12-week fall practicum, the teacher candidates will be asked to reflect on their experiences of the mathematics learning experience of children within the public school system and to consider the following questions:

- What does it mean to implement the new mathematics curriculum?
- How are teachers supported?
- How are curriculum materials chosen?
- Is there an identifiable system of mathematics leadership?
- How appropriate is the direction of mathematics reform for all teachers and all students?
- How can we make a positive difference for students of mathematics at all levels?

During the weeks at the Faculty of Education, we will meet formally to discuss the teacher candidates' experiences and reflections and examine the views of critics and defenders of the mathematics reform movement in its current form. Specifically we will explore the following issues:

- What does it mean to implement the new 'vision' for mathematics?
- What mathematics is important?
- What supports teachers as they change their practice?

- What leadership models are successful in reform efforts?
- What is the role of community members and parents?
- What role does assessment play in mathematics reform?
- How can we strive for excellence and equity?
- Why is change so hard?
- What have we learned for the future?

All teacher candidates will be required to present a seminar and participate in other seminars as audience, moderators (1 seminar), discussant (2 seminars), and/or 'resident expert' (2 seminars). Examples of seminar topics are:

- Teachers and students: confronting one's own mathematics miseducation;
- Becoming a mathematical thinker and teaching for understanding;
- The stages of development in transforming mathematics instruction;
- Resources for teachers;
- What is so special about mathematics?
- Can traditional teachers transform their practice?
- Can computer technology transform mathematics education?
- Can an arts-based approach transform mathematics education?
- Becoming a leader: a new conception of leadership.

**Conclusion.** There is a great need for mathematics leadership at the elementary school level. Since most boards have eliminated specialized mathematics positions such as coordinator or consultant and are using a 'school-based' leadership model, there are few resources for educators in schools to receive information about mathematics resources and appropriate pedagogy. We know that the new Ontario mathematics curriculum challenges us to help students make sense of traditional topics and encourages us as teachers to offer students more opportunities to explore more novel topics such as probability and statistics. It advocates the design of more technology-based courses and asks us to help students to reason with, communicate about and apply mathematics in real-world contexts. These goals are not synchronous with the experiences of most elementary teachers, most of whom are female and many of whom are math-anxious, if not math-phobic.

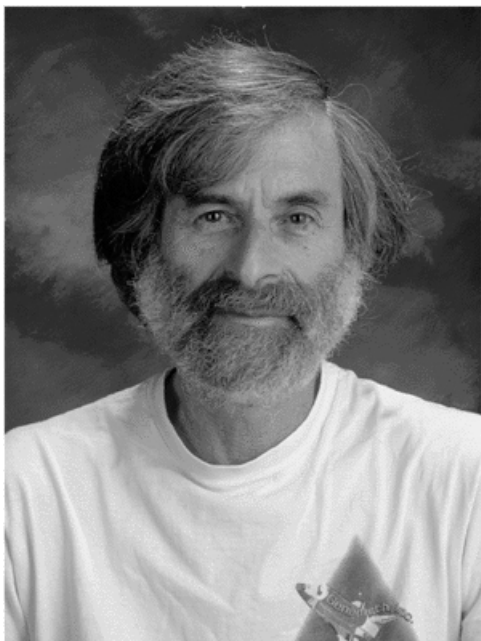
The proposed Focus course could fill a gap as well as meet the needs of our students, our school partners and the College of Teachers.

By July 2001, I will have completed the first major report on the success of these courses, but throughout the year, I will post preliminary findings on the *Connect-Me* website. You are invited to visit us at <http://hydra.educ.queensu.ca/connect-me/>.

Lynda Colgan

## Interview with Leslie Lamport

*A great deal of mathematics is typeset in  $\text{\TeX}$  or  $\text{\LaTeX}$ . This has changed the face of published mathematics and revolutionized mathematical publishing. It has also changed mathematical thinking, although people have not (yet) begun to write  $\sqrt{2}$  on the blackboard in place of the traditional symbol. Günter Ziegler, the editor of the “DMV Mitteilung”, the newsletter of the German mathematical association Deutschen Mathematiker-Vereinigung, where this interview originally appeared, took “about 20 years of  $\text{\LaTeX}$ ” as an opportunity to talk with Leslie Lamport, the author of  $\text{\LaTeX}$ . Reprinted with permission.*



Leslie Lamport

*How were your own first papers produced? Did you start out on a typewriter?*

Typically, when writing a paper, I would write a first draft in pen, then go to typewritten drafts. I would edit each typed draft with pencil or pen until it became unreadable, and would then type the next draft. I think I usually had two typewritten drafts. I would then have a secretary produce a nicely typed “final” version, which would usually be subject only to minor changes. I went on-line around 1977, using TV edit and a primitive text-formatting system that I believe was called Pub. I switched to Scribe when it became available (maybe 1978?) and switched to  $\text{\TeX}$  perhaps a year later. I first used Unix when I moved to DEC in 1985, so I was never a \*roff user.

*Could you tell us about the pre-history: Don Knuth wrote  $\text{\TeX}$  in the seventies. It worked but was hard to use. People*

*tried, some wrote macros, . . . What was the situation when you “got started”?*

When Don was creating  $\text{\TeX}$ 80(?), the second version of  $\text{\TeX}$ , the popular macro package at the time was one written by Max Diaz – I’ve forgotten its name. I was in the process of starting to write a book, and I found Diaz’s macros inadequate. So, I needed to write a set of macros for the book. I figured that, with a little extra effort, I could make a macro package that could be used by other people as well. That was the origin of  $\text{\LaTeX}$ .

*Was this always meant to be “free software”? Did you ever try to “get rich” with it? Do you regret that you didn’t?*

At the time, it never really occurred to me that people would pay money for software. I certainly didn’t think that people would pay money for a book about software. Fortunately, Peter Gordon at Addison-Wesley convinced me to turn the  $\text{\LaTeX}$  manual into a book. In retrospect, I think I made more money by giving the software away and selling the book than I would have by trying to sell the software. I don’t think  $\text{\TeX}$  and  $\text{\LaTeX}$  would have become popular had they not been free. Indeed, I think most users would have been happier with Scribe. Had Scribe been free and had it continued to be supported, I suspect it would have won out over  $\text{\TeX}$ . On the other hand, I think it would have been supplanted more quickly by Word than  $\text{\TeX}$  has been.

*Tell us about your “comic/tragic experiences trying to get computer scientists and computer science journals to enter the computer age.”*

People will go to great lengths to avoid having to change what they do. In the early days of  $\text{\LaTeX}$ , my colleagues at SRI would always tell me that they would write their next paper in  $\text{\LaTeX}$ . A few years ago I got fed up with the fact that computer science journals were still sending around paper manuscripts for review. I circulated a message saying that computer scientists should refuse to review paper manuscripts – except in unusual circumstances, such as submissions from third-world countries. One editor complained that she was handling so many papers that the cost of disk storage for all of them would have been prohibitive. A simple calculation showed that, with disk prices at the time, the storage would have cost about \$250 – less than the cost of the filing cabinet she was then using. (Now, of course, it would be about \$2.50.)

In the late 80’s, I proposed to the ACM that they should create standard document styles or macro packages for what were then the three major formatting programs,  $\text{\TeX}$ /  $\text{\LaTeX}$ , troff, and Scribe. While their journals would accept paper submissions as usual, authors who submitted papers electronically in one of those styles would have the benefit of electronic transmission speeds. An editor at ACM dismissed the idea because it was unfair to force people who didn’t have

access to computers to submit their papers electronically. (I can assure you that I'm not making this up; my imagination isn't that fertile.)

People will switch to something new only if they're forced to by circumstances. People started using  $\text{\TeX}$  because pencil and paper became untenable as a way to produce mathematical documents. Journals started accepting electronic submissions when it became impossible to ignore the Internet any longer.

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### **I'm pessimistic about software in general.**

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#### *Is $\text{\LaTeX}$ hard to use?*

It's easy to use—if you're one of the 2% of the population who thinks logically and can read an instruction manual. The other 98% of the population would find it very hard or impossible to use.

*Why is there no high/same-quality WYSIWYG system available?*

The entrance barrier is too high. To have any chance of success, a system would have to do everything that  $\text{\TeX}$  does. That makes it too much work for any individual. A company like Microsoft could do it; I presume they don't because the market is too small. I occasionally think of going over to the Dark Side and proposing to Microsoft that they hire me and put me in charge of a group to develop such a system. Fortunately, I have other things to do that keep me out of trouble.

The speed of modern computers has removed some of the allure of WYSIWYG.  $\text{\TeX}$  can process a 10-page paper in a couple of seconds. I have a simple Emacs macro that, with a single keystroke, processes and redisplayes the paper I'm working on. So, when I'm writing a paper, I just have to type  $\text{\TeX}$  source, I don't have to read it.

*It's nearly frightening to what extent  $\text{\LaTeX}$  has now "solved all the problems" and seems to be without any (?) competitors?*

It doesn't have any competitors in the technical sense of competition – that is, there's no other system that can do what it does. In the Darwinian sense, its competition is much too strong for it to survive. Kids these days use Word. As I already said, people are extremely reluctant to learn something new. When those kids grow up, they're not going to want to learn a new, arcane system. So, I expect the use of  $\text{\TeX}$  and  $\text{\LaTeX}$  to die out. However, a mathematician just assured me that there is no alternative for math and physics, and he expects  $\text{\TeX}$  to survive the 100 years that Don predicted. We'll see.

*You say that people/kids won't "want to learn a new, arcane system." Couldn't it be fun (!) to learn that certain things don't work, exactly because one had made a logical error?  $\text{\LaTeX}$  as a computer game?*

It's naive to expect something like  $\text{\LaTeX}$  that's at best going to be used only by professional mathematicians and scientists, to filter down to the grade-school level. Even if

there were some point to teaching kids such an esoteric system, it couldn't be done for the same reason that it's been impossible to raise the level of math and science education in this country – namely, kids can't learn from teachers who don't know the subject well, and people who are good in math and science don't become grade-school teachers.

*Here is a recent email dialogue I had with a colleague in Toronto:*

```
>
> "Guenter M. Ziegler" wrote:
>
> >
> > Charming: people [CS professors!!]
> > still use troff! Weren't they forced by
> > law at some point to adopt TeX?
>
> Can't help it, I prefer to type, .NH 3 than
> /subsection etc.
> But then I love unix's two letter commands also!
>
> By the way I can type , eg., .NH 6, does latex
> use /subsubsubsubsubsection ?
>
```

#### *Please comment.*

The use of `\subsection` instead of `\sss` was a deliberate choice – inspired by Scribe – to make command names understandable instead of short. I think that was a good choice. The user who hates to type can always define `\sss` to mean `\subsection`. However, a technical writer typically spends many hours per page writing a document, and the time spent actually typing text is a negligible part of the work. That's probably why neither I nor anyone I know bothers defining shorter synonyms for commands.

One can argue that the use of `\subsection` etc. instead of `\section{3}` was a mistake. However, rather than `\section{3}`, a more logical approach would be a `\heading` command that creates a section heading at the current level, and commands to increase and decrease the current heading level. My feeling now is that the intuitive simplicity of the current system outweighs the advantages of the logical approach; but others might certainly disagree.

One thing along those lines that definitely was a mistake was the use of `\small`, `\large`, etc. instead of a `\size{n}` command along with commands to increase or decrease the size. I'm afraid I just copied the size-changing commands from Scribe without thinking.

*Any regrets about things you should have done better when you "did it"? Lessons to be learned from that? (Knuth has published parts of his log books ...)*

There are lots of mistakes that I made – such as the size-changing commands. But those are inevitable. You can find many of them by looking at the differences between  $\text{\LaTeX}$  2.09 and  $\text{\LaTeX}$  2e. But the biggest mistake I made was not in how I designed  $\text{\LaTeX}$ , but in how I didn't design  $\text{\TeX}$ . When Don was writing  $\text{\TeX}$ 80, he announced that it would

be a reimplementation of  $\text{\TeX}$ 78 but he was not going to add new features. I took him seriously and asked for almost no changes to  $\text{\TeX}$  itself. The only change I can remember strongly urging involved page breaking. People who used  $\text{\TeX}$ 78 will remember that, when  $\text{\TeX}$  couldn't find a good page break, it would very often produce a horrible one – a page containing two or three lines. I felt that this would be a real show-stopper – much worse than words extending to the right of the margin – so I lobbied hard for the change. However, there were many other improvements that I could have suggested but didn't. In the end, Don wound up making very big changes to  $\text{\TeX}$ 78. But they were all incremental, and there was never a point where he admitted that he was willing to make major changes. Had I known at the beginning how many changes he would be making, I would have tried to participate in the redesign. Don had a small group of helpers – mostly students – with whom he met regularly. I could have joined that group and perhaps have had some influence on the design. Who knows, maybe I could have persuaded him to replace  $\text{\TeX}$ 's macro-expansion language with something better. A macro-expansion language is good for a quick-and-dirty solution, so it was appropriate for  $\text{\TeX}$ 78. But it's not good for serious programming because you always have to fight to get things expanded at the right time.

*Three  $\text{\TeX}$  mistakes that people should stop making?*

1. Worrying too much about formatting and not enough about content. 2. Worrying too much about formatting and not enough about content. 3. Worrying too much about formatting and not enough about content.

*What's your view on mathematical typesetting in the future? Quantum leaps ahead?*

I'm pessimistic about software in general. When computers were the province of the technically sophisticated, people wrote software for technically sophisticated users. Now, technically sophisticated users are an insignificant niche market. Standards are being driven by the marketplace, which cares only about the masses. So, mathematicians have no place in the brave new world of computing. They will have to make do with the same flashy but technically impoverished tools

that the little old lady in Peoria uses. So, you can display video animations on the web, but there's still no good way to display a mathematical equation.

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### Mathematicians have no place in the brave new world of computing.

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The future of technical communication is the World Wide Web and the CD-ROM. There may soon be a window of opportunity for two products: one for "typesetting" math for the Web, and the other for creating CD-ROM textbooks. The proposed standard for adding math features to html will, if adopted, make it possible to produce poorly formatted but readable math html documents.

Computers make possible all sorts of new forms of communication. For example, one can have a sort of permanent workshop which consists of a set of technical presentations combined with a chat room. Based on the chat-room discussions, participants can continually refine the technical presentations. It could be something like a "living Bourbaki" for a subject.

However, mathematicians, like all people, are extremely conservative. For example, they still write proofs essentially the same way they've been doing it for centuries. I believe I've demonstrated in

```
AUTHOR  = "Leslie Lamport",
TITLE    = "How to Write a Proof",
JOURNAL  = "American Mathematical Monthly",
VOLUME   = 102,
NUMBER   = 7,
YEAR     = 1995,
Month    = "August-September",
Pages    = "600--608"
```

that there's a better way. But they are just as reluctant to try it as they are to try anything new. Their excuses make no more sense than the ones I heard 15 years ago to explain why they weren't switching to  $\text{\LaTeX}$ .

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## NEWS FROM DEPARTMENTS

### Université Laval, Québec, PQ

Promotions: André Fortin (Full Professor, August 1, 2000)

Retirements: M. Marie-Louis Lavertu and M. Bernard Aupetit both retired on September 1, 2000 after long and fruitful careers.

Distinctions: Walter Hengartner was named professor emeritus of mathematics in June 2000.

### York University, Toronto, ON

Chair: Tom Salisbury, July 2000.

Appointments: Dong Liang (Assistant Professor, Applied Mathematics, July 2000); Alison Gibbs (Assistant Professor, Statistics, July 2000); Andre Kushniruk (Associate Professor, Information Technology, July 2000) Paul Szeptycky (Associate Professor, Atkinson College, July 2000).

Retirements: Carl Hruska, Donald Solitar.

Awards/Distinctions: Nantel Bergeron, President's Research Excellence Award; George O'Brien, Associate Dean of Faculty of Arts.

Visitors: Alfio Giarlotta (USA/Italy, Set-theoretic topology, September 2000-August 2001); Guang-Da Hu (China, Delay differential equations, neural networks, control, numerical analysis, September 2000-August 2001); Yijun Hu (China, Probability, June 2000-June 2001); Kunquan Lan (Canada, Nonlinear analysis, September 2000-August 2001); Yong Song Qin (China, Statistics, August 2000-April 2001); Joseph So (Canada, Mathematical biology, differential equations, dy-

namical systems, September 2000-December 2001); Shaobin Tan (China, Infinite dimensional Lie algebras and representation theory, July 2000-June 2001); Mike Zabrocki (USA, Algebraic Combinatorics, July 2000-June 2001); Zhou Zhan (China, Delay differential equations, dynamical systems, September 2000-August 2001); Zhongrong Zheng (Canada, Probability).

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## UNIVERSITY OF WATERLOO – WATERLOO, ONTARIO DEPARTMENT OF PURE MATHEMATICS

The Department of Pure Mathematics at the University of Waterloo expects one or more tenure-track positions starting July 1, 2001. Candidates in any area of Pure Mathematics will be considered.

In order to be considered for a position, a Ph.D. is required. Postdoctoral experience is preferred. An appointment will be offered only to someone with very strong research and teaching qualifications. The closing date for receipt for applications is **December 1, 2000**. Applicants should submit their curriculum vitae, together with the names of at least three referees, and should arrange for letters of reference to be sent directly from the referees.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents. The University of Waterloo encourages applications from all qualified individuals, including women, members of visible minorities, native people, and persons with disabilities. This appointment is subject to the availability of funds.

Please send applications to:

**Dr. B. Forrest, Chair,  
Department of Pure Mathematics,  
University of Waterloo,  
Waterloo, Ontario, Canada N2L 3G1  
The department's Web page is at:  
[http://math.uwaterloo.ca/PM\\_Dept/homepage.html/](http://math.uwaterloo.ca/PM_Dept/homepage.html/)**

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## UNIVERSITY OF CALGARY – CALGARY, ALBERTA DEPARTMENT OF MATHEMATICS & STATISTICS

The University of Calgary invites applications for a number of tenure track positions in the Department of Mathematics and Statistics, beginning July 1, 2001.

Outstanding applicants from all areas in Statistics will be considered, but the Department is particularly interested in research expertise in actuarial science, applied statistics, and biostatistics. Candidates in actuarial science should be accredited, or be working towards accreditation, in the Society of Actuaries or Casualty Actuarial Society. Applicants interested in the computational aspects of these areas are especially sought. The successful applicants will have access to the Multimedia Advanced Computation Infrastructure (MACI), a collaborative initiative establishing a new, world-class scientific computing facility in Canada. They also will have access to some of North America's best skiing and hiking.

Please submit a curriculum vitae together with a description of Research Expertise and a short statement about your Teaching Philosophy. Arrange to have three referees send confidential letters to:

**the Search Committee,  
Department of Mathematics and Statistics,  
University of Calgary,  
2500 University Drive NW,  
Calgary, Alberta, T2N 1N4.**

The closing date is **December 15, 2000**.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada. The University of Calgary respects, appreciates and encourages diversity.

## CALL FOR NOMINATIONS / APPEL DE CANDIDATURES

### 2001 Canadian Mathematical Society Doctoral Prize Le Prix de doctorat 2001 de la Société mathématique du Canada

The CMS Doctoral Prize recognizes outstanding performance by a doctoral student. The prize is awarded to the person who received a Ph.D. from a Canadian university in the preceding year (January 1st to December 31st) and whose overall performance in graduate school is judged to be the most outstanding. Although the dissertation will be the most important criterion (the impact of the results, the creativity of the work, the quality of exposition, etc.) it will not be the only one. Other publications, activities in support of students and other accomplishments will also be considered.

Individuals who made a nomination last year can renew this nomination by simply indicating their wish to do so by the deadline date. Only materials updating the 2000 nomination need be provided as the original has been retained.

The CMS Doctoral Prize will consist of an award of \$500, a two-year complimentary membership in the CMS, a framed Doctoral Prize certificate and a stipend for travel expenses to attend the CMS meeting to receive the award and present a plenary lecture.

#### Nominations

Candidates must be nominated by their university and the nominator is responsible for preparing the documentation described below, and submitting the nomination to the address below.

No university may nominate more than one candidate and the deadline for the receipt of nominations is **January 31, 2001**.

The documentation shall consist of:

- A curriculum vitae prepared by the student.
- A résumé of the student's work written by the student and which must not exceed ten pages. The résumé should include a brief description of the thesis and why it is important, as well as of any other contributions made by the student while a doctoral student.
- Three letters of recommendation of which one should be from the thesis advisor and one from an external reviewer. A copy of the external examiner's report may be substituted for the latter. More than three letters of recommendation are not accepted.

La SMC a créé ce Prix de doctorat pour récompenser le travail exceptionnel d'un étudiant au doctorat. Le prix sera décerné à une personne qui aura reçu son diplôme de troisième cycle d'une université canadienne l'année précédente (entre le 1<sup>er</sup> janvier et le 31 décembre) et dont les résultats pour l'ensemble des études supérieures seront jugés les meilleurs. La dissertation constituera le principal critère de sélection (impact des résultats, créativité, qualité de l'exposition, etc.), mais ne sera pas le seul aspect évalué. On tiendra également compte des publications de l'étudiant, de son engagement dans la vie étudiante et de ses autres réalisations.

Il est possible de renouveler une mise en candidature présentée l'an dernier, pourvu que l'on en manifeste le désir avant la date limite. Dans ce cas, le présentateur n'a qu'à soumettre des documents de mise à jour puisque le dossier original a été conservé.

Le lauréat du Prix de doctorat de la SMC aura droit à une bourse de 500 \$. De plus, la SMC lui offrira l'adhésion gratuite à la Société pendant deux ans et lui remettra un certificat encadré et une subvention pour frais de déplacements lui permettant d'assister à la réunion de la SMC où il recevra son prix et présentera une conférence.

#### Candidatures

Les candidats doivent être nommés par leur université; la personne qui propose un candidat doit se charger de regrouper les documents décrits aux paragraphes suivants et de faire parvenir la candidature à l'adresse ci-dessous.

Aucune université ne peut nommer plus d'un candidat. Les candidatures doivent parvenir à la SMC au plus tard **le 31 janvier 2001**.

Le dossier sera constitué des documents suivants :

- Un curriculum vitae rédigé par l'étudiant.
- Un résumé du travail du candidat d'au plus dix pages, rédigé par l'étudiant, où celui-ci décrira brièvement sa thèse et en expliquera l'importance, et énumérera toutes ses autres réalisations pendant ses études de doctorat.
- Trois lettres de recommandation, dont une du directeur de thèse et une d'un examinateur de l'extérieur (une copie de son rapport fera aussi l'affaire). Le comité n'acceptera pas plus de trois lettres de recommandation.

Chair/Président

Doctoral Prize Selection Committee/Comité de sélection du Prix de doctorat

CMS Executive Office/Bureau administratif de la SMC

577 King Edward, Suite 109

P.O. Box 450, Station A/C.P. 450, Succursale A

Ottawa, Ontario Canada

K1N 6N5

## 2000 ENDOWMENT GRANTS COMPETITION

## CONCOURS DE BOURSES DU FONDS DE DOTATION 2000

### CALL FOR PROPOSALS / APPEL DE PROPOSITIONS

The Canadian Mathematical Society is pleased to announce a new grants competition to fund projects that contribute to the broader good of the mathematical community. A portion of the annual income from the CMS Endowment Fund will be used to fund such projects and an Endowment Grants Committee (EGC) will administer the distribution of the grants and will adjudicate proposals for projects.

Proposals must address the goal and statement of purpose of the Canadian Mathematical Society:

The goal of the Canadian Mathematical Society is to support the promotion and advancement of the discovery, learning, and application of mathematics. The CMS Statement of Purpose is:

1. To unify and support Canadian mathematicians through effective communication, broad membership, sponsorship of diverse activities, and partnerships with like professional societies.
2. To support mathematics research through the communication of current research to both the specialist and non-specialist, public recognition of research accomplishments and collaboration with the research institutes and granting agencies.
3. To support the advancement of mathematics education through joint projects with mathematics educators at all levels, promotion of educational advancements, and partnerships with provincial ministries of education and organizations supporting mathematics education.
4. To champion mathematics through initiatives that explain, promote and increase the general understanding of mathematics, provide extra-curricula opportunities for students, and encourage partnerships with corporate, government and not-for-profit agencies.

An applicant may be involved in only one proposal per competition as a principal applicant. Proposals must come from CMS members, or, if joint, at least one principal applicant must be a CMS member.

The EGC will consider funding proposals for a maximum of three years. However, multi-year proposals must be funded from the funds available to the EGC in the year of application. The EGC will consider funding proposals to a maximum of \$5,000 per year.

The EGC committee intends to favour proposals where CMS funds can be leveraged or where proposals have no other natural funding body to which to apply.

If it is anticipated that a proposal will generate something of lasting financial value, proposers must indicate that this is the case and declare their intent with respect to that value.

An application form, advice and directions are available at the CMS website [www.cms.math.ca/Grants/](http://www.cms.math.ca/Grants/). Proposers will have ample opportunity to sell their ideas to the EGC.

We hope to be able to have an applicant fill out the application on an HTML form and submit it electronically. If that does not work, we will accept a hard copy as an e-mail attachment using either the Microsoft Word template or the  $\LaTeX$  template available for downloading from the CMS web site given above. Send the proposal as an attachment to the e-mail address [chair-egc@cms.math.ca](mailto:chair-egc@cms.math.ca). We would also accept a proposal in these templates sent as hard copy to the CMS Executive Office. If you have any immediate questions on the program or the application process please e-mail the Chair of the EGC, J. G. Timourian, at [chair-egc@cms.math.ca](mailto:chair-egc@cms.math.ca). If you plan on applying, the committee would find it extremely useful if you sent the Chair an e-mail expressing your interest as soon as possible.

Proposals must be received at the CMS Executive Office or electronically by the EGC committee no later than **October 31, 2000**.

Proposals should be sent to the following address:  
 2000 CMS Endowment Grants Competition  
 Canadian Mathematical Society  
 577 King Edward, Suite 109  
 P.O. Box 450, Station A  
 Ottawa, Ontario  
 K1N 6N5

Again, the relevant electronic addresses are [www.cms.math.ca/Grants/](http://www.cms.math.ca/Grants/) for directions, forms, advice and electronic form submission; [chair-egc@cms.math.ca](mailto:chair-egc@cms.math.ca) for e-mail contact with the Chair of the EGC and for submission of a proposal as an attached file to an e-mail.

\*\*\*\*\*

La Société mathématique du Canada (SMC) est heureuse d'annoncer la tenue d'un nouveau concours de bourses pour le financement d'activités qui contribuent à l'essor global de la communauté mathématique. Une partie des recettes annuelles tirées du Fonds de dotation de la SMC servira à financer de telles activités. Le Comité d'attribution des bourses



du fonds de dotation (CABFD) se chargera d'évaluer les propositions et d'attribuer les bourses.

Les propositions doivent être conformes à l'objectif et à l'énoncé d'intention de la SMC :

La Société mathématique du Canada s'est donnée pour objectif de promouvoir et de favoriser la découverte et l'apprentissage des mathématiques, et les applications qui en découlent. Son énoncé d'intention est le suivant :

1. Regrouper et appuyer les mathématiciens canadiens en favorisant la communication et l'adhésion à grande échelle, en commanditant diverses activités et en établissant des partenariats avec des associations professionnelles semblables à la nôtre.
2. Encourager la recherche mathématique en diffusant les résultats de recherches en cours aux spécialistes et aux non-spécialistes, en faisant reconnaître publiquement les travaux de chercheurs et en collaborant avec les instituts de recherche et les organismes subventionnaires.
3. Favoriser l'apprentissage des mathématiques en réalisant des projets avec des professeurs de mathématiques de tous les niveaux, en faisant connaître les progrès dans l'enseignement et en établissant des partenariats avec les ministères de l'éducation provinciaux et les organismes voués à l'apprentissage des mathématiques.
4. Défendre les mathématiques en créant des initiatives visant à expliquer, à promouvoir et à mieux faire connaître la discipline, en organisant des activités parascolaires et en encourageant les partenariats avec les sociétés privées, les gouvernements et les organismes à but non lucratif.

Un demandeur ne peut présenter qu'une proposition par concours en tant que demandeur principal. Les propositions doivent venir de membres de la SMC. S'il s'agit d'un projet conjoint, au moins un des demandeurs principaux doit être membre de la SMC.

Le CABFD évaluera les projets qui s'étalent sur un maximum de trois ans. Les projets s'échelonnant sur plusieurs années seront toutefois financés en fonction des fonds dont

disposera le Comité l'année de la demande. Le Comité se limitera aux propositions dont le financement demandé n'excède pas 5 000 \$ par année.

Le CABFD désire privilégier les propositions où les fonds de la SMC peuvent être équilibrés ou les propositions qui ne disposent d'aucun organisme de financement naturel où postuler.

Si les demandeurs prévoient tirer une valeur financière durable du projet, ils doivent l'indiquer et expliquer ce qu'ils ont l'intention d'en faire.

Le formulaire de demande, les instructions pertinentes et des conseils est disponible au site de la SMC [www.smc.math.ca/Grants/](http://www.smc.math.ca/Grants/). Ainsi, les proposants auront tout le temps voulu pour vendre leurs idées au CABFD.

Nous espérons qu'il sera possible de remplir la demande en format HTML et de la soumettre électroniquement mais sinon, nous accepterons les fichiers annexés à un message de courriel réalisés à l'aide des documents types de format Microsoft Word ou  $\text{\LaTeX}$  téléchargeables à partir du site Web de la SMC, à l'adresse suivante : [pres-egc@smc.math.ca](mailto:pres-egc@smc.math.ca). Nous accepterons aussi les copies imprimées de ces documents types au bureau administratif de la SMC. Pour toute question sur le programme ou sur le processus de demande, prière d'envoyer un message par courriel au président du CABFD, J. G. Timourian, à l'adresse suivante : [pres-egc@smc.math.ca](mailto:pres-egc@smc.math.ca). Si vous prévoyez faire une demande, le Comité vous saurait gré de lui faire part de votre intérêt le plus tôt possible en faisant parvenir un message par courriel à son président.

Les propositions doivent parvenir au bureau administratif de la SMC au plus tard **le 31 octobre 2000**.

Envoyer les propositions à l'adresse suivante :  
Concours de bourses du fonds de dotation 2000  
Société mathématique du Canada  
577, avenue King-Edward, bureau 109  
C. P. 450, succursale A  
Ottawa (Ontario) K1N 6N5

Rappel - liste des adresses pertinentes :  
[www.smc.math.ca/Grants/](http://www.smc.math.ca/Grants/) : instructions, formulaires, conseils, envoi du formulaire électronique; [pres-egc@smc.math.ca](mailto:pres-egc@smc.math.ca) : pour communiquer avec le président du CABFD et envoyer vos demandes en annexe à un message de courriel.

### Did you know? ...

The CMS Office is on the University of Ottawa campus. All correspondence from participating Ontario universities can be sent IUTS - **free of charge**.

### Saviez-vous que? ...

Le Bureau administratif de la SMC est situé sur le campus de l'Université d'Ottawa. Toute correspondance provenant d'une université ontarienne peut être envoyée **gratuitement** via IUTS.

**McMASTER UNIVERSITY – HAMILTON, ONTARIO**  
**DEPARTMENT OF MATHEMATICS & STATISTICS**  
**Number Theory**

The Department of Mathematics & Statistics, McMaster University, invites applications for a tenure track Assistant or Associate Professorship starting July 1, 2001.

Candidates should have a Ph.D. and a research record of high quality in a major area of Number Theory, as well as demonstrated interest and ability in teaching. The salary and rank will be based on qualifications and experience.

McMaster is committed to Employment Equity and encourages applications from all qualified candidates, including aboriginal peoples, persons with disabilities, members of visible minorities and women.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

Applications, including curriculum vitae and three letters of reference, should be received before **November 15, 2000** by:

**E. Sawyer, Acting Chair**  
**Mathematics & Statistics**  
**McMaster University**  
**Hamilton, Ontario**  
**Canada, L8S 4K1**

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**McMASTER UNIVERSITY – HAMILTON, ONTARIO**  
**DEPARTMENT OF MATHEMATICS & STATISTICS**  
**Algebraic Geometry & Number Theory**

The Department of Mathematics & Statistics, McMaster University, invites applications for a tenured faculty position in Mathematics at the rank of Associate Professor or Professor, with anticipated starting date July 1, 2001.

The successful candidate should be internationally recognized for his or her fundamental contributions to research in a major area of Algebraic Geometry or Number Theory, be actively engaged in significant research projects, and have demonstrated excellence in teaching. Research areas of particular interest to the Department include Arithmetic Algebraic Geometry, Algebraic Number Theory and related areas.

For an appointment at the level of Professor of Mathematics the successful candidate should have attracted substantial research grant support and demonstrated leadership in organizing research efforts through the supervision of graduate students and postdoctoral researchers.

The salary and rank will be based on qualifications and experience.

McMaster is committed to Employment Equity and encourages applications from all qualified candidates, including aboriginal peoples, persons with disabilities, members of visible minorities and women.

In accordance with Canadian Immigration requirements, Canadian citizens and permanent residents of Canada will be considered first for this position.

Applications, including curriculum vitae and three letters of reference, should be received before **November 15, 2000** by:

**E. Sawyer, Acting Chair**  
**Mathematics & Statistics**  
**McMaster University**  
**Hamilton, Ontario**  
**Canada, L8S 4K1**

**McMASTER UNIVERSITY – HAMILTON, ONTARIO**  
**DEPARTMENT OF MATHEMATICS & STATISTICS**  
**Statistics**

The Department of Mathematics Statistics, McMaster University, invites applications for a tenure track Assistant or Associate Professorship starting July 1, 2001.

Candidates should have a Ph.D. and a research record of high quality in a major area of Statistics, as well as demonstrated interest and ability in teaching. The salary and rank will be based on qualifications and experience.

McMaster is committed to Employment Equity and encourages applications from all qualified candidates, including aboriginal peoples, persons with disabilities, members of visible minorities and women.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

Applications, including curriculum vitae and three letters of reference, should be received **before November 15, 2000** by:

**E. Sawyer, Acting Chair**  
**Mathematics & Statistics**  
**McMaster University**  
**Hamilton, Ontario**  
**Canada, L8S 4K1**

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**UNIVERSITY OF TORONTO – TORONTO, ONTARIO**  
**DEPARTMENT OF MATHEMATICS**  
**Tenure-Stream Appointment in Mathematics**

The Department of Mathematics, University of Toronto solicits applications for a tenure-stream appointment in Mathematics. Preference will be given to researchers in the areas of partial differential equations, stochastic differential equations or modelling. The appointment is at the downtown (St. George) campus at open rank, to begin July 1, 2001. Salary commensurate with experience. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

**Search Committee**  
**Department of Mathematics**  
**University of Toronto**  
**100 St. George Street, Room 4072**  
**Toronto, Canada M5S 3G3**

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: <http://www.math.toronto.edu/jobs/>. To ensure full consideration, this information should be received **by November 15, 2000**. The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas. In accordance with Canadian immigration requirements this advertisement is directed to Canadian citizens and permanent residents of Canada.

**UNIVERSITY OF TORONTO – TORONTO, ONTARIO**  
**DEPARTMENT OF MATHEMATICS**  
**Tenure-Stream Appointment in Applied Mathematics – Computational Science**

The Department of Mathematics, University of Toronto solicits applications for a tenure-stream appointment for a mathematician working in the area of Applied Mathematics (Computational Science).

The appointment is at the downtown (St. George) campus at the level of Assistant Professor, to begin July 1, 2001. Salary commensurate with experience. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

**Search Committee**  
**Department of Mathematics**  
**University of Toronto**  
**100 St. George Street, Room 4072**  
**Toronto, Canada M5S 3G3**

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: <http://www.math.toronto.edu/jobs/>. To ensure full consideration, this information should be received **by November 15, 2000**.

The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

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**UNIVERSITY OF TORONTO – TORONTO, ONTARIO**  
**DEPARTMENT OF MATHEMATICS**  
**Tenure-Stream Appointment in Algebra, Number Theory and Geometry**

The University of Toronto solicits applications for a tenure-stream appointment in the fields of Algebra, Number Theory and Geometry. Preference will be given to researchers in arithmetic geometry.

The appointment is at the downtown (St. George) campus at the level of Assistant Professor, to begin July 1, 2001. Salary commensurate with experience. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to Mathematics.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

**Search Committee**  
**Department of Mathematics**  
**University of Toronto**  
**100 St. George Street, Room 4072**  
**Toronto, Canada M5S 3G3**

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: <http://www.math.toronto.edu/jobs/>. To ensure full consideration, this information should be received **by November 15, 2000**.

The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

**UNIVERSITY OF TORONTO – TORONTO, ONTARIO**  
**DEPARTMENT OF MATHEMATICS**  
**Tenure-Stream Appointment in Applied Mathematics**

The Department of Mathematics, University of Toronto solicits applications for a tenure-stream appointment for a mathematician working in the area of Applied Mathematics.

The appointment is at the downtown (St. George) campus at the level of Assistant Professor, to begin July 1, 2001. Salary commensurate with experience. Candidates are expected to have demonstrated excellence in both teaching and research after the Ph.D.; in particular, a candidate's research record should show clearly the ability to make significant original and independent contributions to mathematics.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least four letters of reference sent directly to:

**Search Committee**  
**Department of Mathematics**  
**University of Toronto**  
**100 St. George Street, Room 4072**  
**Toronto, Canada M5S 3G3**

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available from our World Wide Web Employment Opportunities page: <http://www.math.toronto.edu/jobs/>. To ensure full consideration, this information should be received **by November 15, 2000**. The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

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**UNIVERSITY OF TORONTO – TORONTO, ONTARIO**  
**DEPARTMENT OF MATHEMATICS**  
**Limited Term Assistant Professorships**

The Department invites applications for one or more limited term Assistant Professorships which may, subject to budgetary approval, become available on either the St. George (downtown), Scarborough or Erindale campus, for a period of one to three years, beginning July 1, 2001. Duties consist of teaching and research, and candidates must demonstrate clear strength in both. Preference will be given to candidates with recent doctoral degrees. Salaries commensurate with qualifications.

Applicants should send their complete C.V. including a list of publications, a short statement describing their research programme, and all appropriate material about their teaching. They should also arrange to have at least three letters of reference sent directly to:

**Search Committee**  
**Department of Mathematics**  
**University of Toronto**  
**100 St. George Street, Room 4072**  
**Toronto, Canada M5S 3G3**

At least one letter should be primarily concerned with the candidate's teaching. In addition, it is recommended that applicants submit the electronic application form which is available on our World Wide Web Employment Opportunities page: <http://www.math.toronto.edu/jobs/>. To ensure full consideration, all information should be received **by November 15, 2000**. Further information about academic positions in the Department of Mathematics is available on the World Wide Web by accessing the above URL.

The University of Toronto is strongly committed to diversity within its community. The University especially welcomes applications from visible minority group members, women, Aboriginal persons, persons with disabilities, and others who may add to the diversity of ideas.

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents of Canada.

## THE UNIVERSITY OF WESTERN ONTARIO – LONDON, ONTARIO DEPARTMENT OF MATHEMATICS

Applications are invited for a tenure track position at the Assistant Professor level.

The successful candidate will have an outstanding record of research and publication in a field related to one of the existing areas of research strength of the Department in algebra, analysis and topology, and will be expected to maintain an ongoing vigorous research program. The candidate will also have a commitment to and demonstrated aptitude for teaching, and will be expected to teach at the undergraduate and graduate levels and to supervise graduate theses.

Those interested in applying for this position should forward a curriculum vitae and have at least three letters of reference sent to:

**Prof. J. F. Jardine, Chair**  
**Department of Mathematics**  
**The University of Western Ontario**  
**London, Ontario N6A 5B7**  
**Canada**

At least one letter of reference should include a detailed comment on the teaching abilities of the applicant.

We also welcome e-mail inquiries and submissions, to be sent to the address: [math-pos@julian.uwo.ca](mailto:math-pos@julian.uwo.ca). Our web address is <http://www.math.uwo.ca>.

Application materials should arrive **no later than January 12, 2001**. The appointment is scheduled to begin on July 1, 2001. Positions are subject to budget approval. In accordance with Canadian Immigration requirements, this advertisement is directed to Canadian citizens and Permanent Residents. The University of Western Ontario is committed to employment equity, welcomes diversity in the workplace, and encourages applications from all qualified individuals including women, members of visible minorities, aboriginal persons, and persons with disabilities.

## CALENDAR OF EVENTS / CALENDRIER DES ÉVÉNEMENTS

### OCTOBER 2000

**20–22** One Hundred Years of L'Enseignement Mathématique Symposium (Geneva)

<http://elib.zib.de/IMU/ICMI/>; [EnsMath@math.unige.ch](mailto:EnsMath@math.unige.ch)

**23–27** Vertex Operator Algebras in Mathematics and Physics (University of Toronto)

<http://www.fields.utoronto.ca>, [lietheory@fields.utoronto.ca](mailto:lietheory@fields.utoronto.ca)

**23–27** Applications to Quantum Field Theory, A Newton Institute EuroWorkshop (Isaac Newton Institute for Mathematical Sciences, Cambridge, UK)

<http://www.newton.cam.ac.uk>

### NOVEMBER 2000

**18–22** International Conference on “Mathematics for Living” (Jordan)

<http://www.vsg.edu.au/egypt99/>

### DECEMBER 2000

**9–13** The Ninth International Workshop on Matrices and Statistics, in celebration of C.R.Rao's 80th birthday, (Osmania University, Hyderabad, India).

<http://eos.ect.uni-bonn.de/HYD2000.htm>

**10–12 CMS Winter Meeting / Réunion d'hiver de la SMC (Hotel Vancouver, Vancouver, B. C.)**

<http://www.cms.math.ca/CMS/Events/winter00>

### OCTOBRE 2000

### NOVEMBRE 2000

### DÉCEMBRE 2000

### JANUARY 2001

**9–14** Quasiclassical and Quantum Structures, in the Symplectic Topology, Geometry, and Gauge Theory Program (Fields Institute, Toronto and CRM, Montreal)

<http://www.fields.utoronto.ca/symplectic.html>

**10–13** Joint Mathematics Meeting. AMS MAA (New Orleans Marriott ITT Sheraton New Orleans Hotel, New Orleans, Louisiana)

<http://www.ams.math.org/meetings/>

### MARCH 2001

**25–30** Sixth International Conference on Approximation and Optimization, (Guatemala City, Guatemala)

<http://www.ing.usac.edu.gt/apopt6/>

**26–April 7** Symplectic and Contact Topology, Field Theory and Higher Dimensional Gauge Theory, in the Symplectic Topology, Geometry, and Gauge Theory Program (Fields Institute, Toronto and CRM, Montreal)

<http://www.fields.utoronto.ca/symplectic.html>

### MAY 2001

**25–29** Annual meeting of the Canadian Mathematics Education Study Group, (University of Alberta, Edmonton)

<http://cmesg.math.ca>

### JANVIER 2001

### MARS 2001

### MAI 2001

**JUNE 2001**

**2–4 CMS Summer Meeting / Réunion d'été de la SMC**  
(University of Saskatchewan, Saskatoon, Saskatchewan)

<http://www.cms.math.ca/CMS/Events/summer01>

**4–13 Hamiltonian Group Actions and Quantization**, in the  
Symplectic Topology, Geometry, and Gauge Theory Program  
(Fields Institute, Toronto and CRM, Montreal)

<http://www.fields.utoronto.ca/symplectic.html>

Canadian Mathematics Education Study Group Meeting  
(University of Alberta, Edmonton)

Annual Meeting of the Statistical Society of Canada  
(Vancouver, British Columbia)

**DECEMBER 2001****DÉCEMBRE 2001**

**8–10 CMS Winter Meeting / Réunion d'hiver de la SMC**  
(Toronto Colony Hotel, Toronto, Ontario)

<http://www.cms.math.ca/CMS/Events/winter01>

**MAY 2002****MAI 2002**

**3–5 AMS Eastern Section Meeting** (CRM, Université de  
Montreal)

<http://www.ams.math.org/meetings/>

**JUNE 2002**

**CMS Summer Meeting / Réunion d'été de la SMC**  
(Université Laval, Québec, Québec)

Monique Bouchard: [meetings@cms.math.ca](mailto:meetings@cms.math.ca)

**AUGUST 2002****AOÛT 2002**

**20–28 International Congress of Mathematicians**,  
(Beijing, China)

[cms@math08.math.ac.cn](mailto:cms@math08.math.ac.cn); <http://icm2002.org.cn/>

**DECEMBER 2002****DÉCEMBRE 2002**

**CMS Winter Meeting / Réunion d'hiver de la SMC**

(University of Ottawa / Université d'Ottawa,  
Ottawa, Ontario)

Monique Bouchard: [meetings@cms.math.ca](mailto:meetings@cms.math.ca)

**JUNE 2003****JUIN 2003**

**CMS Summer Meeting / Réunion d'été de la SMC**  
(University of Alberta, Edmonton, Alberta)

Monique Bouchard: [meetings@cms.math.ca](mailto:meetings@cms.math.ca)

**DECEMBER 2003****DÉCEMBRE 2003**

**CMS Winter Meeting / Réunion d'hiver de la SMC**

(Simon Fraser University, Burnaby, British Columbia)

Monique Bouchard: [meetings@cms.math.ca](mailto:meetings@cms.math.ca)

**RATES AND DEADLINES / TARIFS ET ÉCHÉANCES**

Net rates/Tarifs nets	Institutional Members Membres institutionnels	Corporate Members Membres organisationnels	Others Autres
Full Page	\$ 200	\$ 375	\$ 500
1/2 Page	\$ 120	\$ 225	\$ 300
1/4 Page	\$ 70	\$ 130	\$ 175
Inserts: maximum 4 pages	\$ 160	\$ 300	\$ 400
Surcharges apply for prime locations - contact <a href="mailto:notes@cms.math.ca">notes@cms.math.ca</a> Des suppléments sont applicables pour des places de choix - communiquer avec <a href="mailto:notes@smc.math.ca">notes@smc.math.ca</a>			

Issue/Numéro:	Deadline/Date limite:
February/février	December 1 décembre
March/mars	January 15 janvier
April/avril	February 15 février
May/mai	March 15 mars
September/septembre	July 1 juillet
October/octobre	August 15 août
November/novembre	September 15 septembre
December/décembre	October 15 octobre
<b>Max. page size/Taille max. des pages:</b> Back page/4e de couverture: 7.5 x 8.5 in./pouces Inside page/page intérieure: 7.5 x 10 in./pouces	

The CMS Notes is mailed in the first week of the issue month. Subscription to the Notes is included with the CMS membership. For non-CMS members, the subscription rate is \$45 (CDN) for subscribers with Canadian addresses and \$45 (US) for subscribers with non-Canadian addresses.

# SPRINGER FOR MATHEMATICS

**New in Softcover**

**PETER WALTERS**, University of Warwick, Coventry, UK

## INTRODUCTION TO ERGODIC THEORY



The first part of the text is concerned with measure-preserving transformations or probability spaces; recurrence properties, mixing properties, the Birkhoff ergodic theorem, isomorphism and spectral isomorphism, and entropy theory are discussed. The second part of the text focuses on the ergodic theory of continuous transformations of compact metrizible spaces. The family of invariant probability measures

for such a transformation is studied and related to properties of the transformation such as topological transitivity, minimality, the size of the non-wandering set, and existence of periodic points.

2000/264 PP., 8 ILLUS./SOFTCOVER  
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GRADUATE TEXTS IN MATHEMATICS, VOL. 79

**New in Softcover**

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