CENTRE DE RECHERCHES MATHÉMATIQUES

Annual Report
1996-1997

Université de Montréal

A WORD FROM THE DIRECTOR

It is gratifying to see that 28 years after its creation, the CRM consistently generates outstanding research programs and initiatives. Internationally renowned, the CRM is playing a leading role in the development of the mathematical sciences in Canada, by supporting research and training projects in both fundamental and applied mathematical sciences, by fostering interdisciplinarity, by reaching out to the business and industrial sectors and by contributing actively to the organization of mathematical research in the country. The year 1996-1997 has seen the CRM more active than ever in all these directions. The present report purports to reflect these activities, some of which I will now highlight.

Every year, a good fraction of the CRM's activities are organized under a special theme. This allows a concentration of expertise in areas of high interest so as to stimulate interactions and give young researchers first class training. It was certainly most opportune to devote 1996-1997 to Discrete Mathematics in view of the recent developments in this vast field and of the importance it has in domains such as computer science, management and engineering. Moreover, despite the presence in Canada of many specialists in Discrete Mathematics, the area had not yet been the object of a special program in this country. The CRM coordinated its activities with those of Berkeley's MSRI which was holding connected events under the same banner during the year. This allowed for an even greater impact of the programs on the discipline.

The CRM special year principally covered two subjects: Combinatorics and Group Theory. In addition to the CRM Summer School in Banff, ten workshops (nine in Montreal, one in Waterloo) focused on various aspects of these two topics. The Aisenstadt chair, which allows the CRM to play host each year to distinguished scientists, is traditionally integrated with the thematic activities. This year, it was held by László Babai from the University of Chicago and the Fields medallist Efim Zelmanov from Yale University. The whole year proved extremely fruitful and I wish to thank all those (organizers, speakers, participants, support staff) who enthusiastically contributed to making this special program such a success.

In 1997-1998, the CRM will be presenting another Canadian première: a full special year in Statistics. A distinguished scientific committee chaired by Nancy Reid is coordinating a program that promises to be very exciting and will involve a large number of the Canadian statisticians. To further develop its links with the Statistics community, the CRM, in collaboration with the Statistical Society of Canada, created the CRM-SSC prize in Statistics. It will be awarded for the first time at the 1998 Annual SSC meeting. The CRM also signed an agreement with Springer-Verlag to establish a CRM Series as part of their main Series in Statistics.

In addition to its thematic activities, the CRM also maintains a general scientific program consisting of timely events held in Montreal and elsewhere. With the cancellation of NSERC's conference grant program, the CRM, along with the other Canadian Institutes, has taken over the responsibility of sponsoring meetings across the country. Some thirteen events were thus organized and funded (in part) by the CRM during 1996-1997. I was proud to be personally involved in the Symposium in honour of Jiří Patera and Pavel Winternitz, two of CRM's distinguished scientists who have contributed enormously to the life of our institute and its international reputation, and in the workshop organized (at no cost to the Canadian taxpayers) by the CRM at the Nankai Institute of Mathematics in China, in the framework of a collaboration agreement between this institute and the CRM.

Apart from the newly created prize in Statistics, three other prizes are sponsored by the CRM. The 1996-1997 recipients were: James Arthur (CRM-Fields Institute prize), Henri Darmon and Lisa Jeffrey (André-Aisenstadt prize) and Ian Affleck (CAP-CRM prize).

The CRM publishing division was very busy this past year with an output of almost one book

per month. I would like to mention two titles in particular: Ioannis Karatzas' "Lectures on the Mathematics of Finance" already advertised as a best-seller by the AMS, and Donald Knuth's "Stable Marriage and its Relation to Other Combinatorial Problems," the English version of Knuth's Aisenstadt Lectures originally published in French by the CRM. As well, close to one hundred and fifty research reports were produced in 1996-1997 by the members of the CRM.

In retrospect, the year 1996-1997 will certainly be remembered for the creation of the Network for Computing and Mathematical Modeling (**nc***m*$_2$), a major and decisive event in the development of industrial mathematics in Canada. Founded in 1996, this university-industry consortium was awarded a five-year grant of $600 K per year by NSERC in the framework of its research network program. Only three such grants were awarded in this year's competition. The **nc***m*$_2$ brings together five major Montreal-based research centres working in related areas and some twenty industrial partners. Apart from the CRM with its tradition in applied mathematics, the research centres are: CERCA, CIRANO, CRT and GERAD. The integration of these research powerhouses in the **nc***m*$_2$ has taken their collective R & D capacity as a network to an extraordinary level. The research program of the **nc***m*$_2$ is organized around three themes: (i) risk management, (ii) information processing, (iii) transportation and telecommunications. The **nc***m*$_2$ has proved very attractive to non-university organizations as it provides a one-stop access to a broad and world class expertise. In leading this initiative, the CRM has shown that mathematical sciences can advantageously compete with other disciplines for the funding of large-scale projects. It also assumed its responsibilities towards the development of career opportunities for its trainees. In its report, the international site visit committee wrote: "With its impressive participant base, it (the **nc***m*$_2$) can arguably become the outstanding industrial-university mathematical research program in the hemisphere." We also think that the potential of the **nc***m*$_2$ is enormous.

In spite of the regional tensions that the NSERC research network competition created, the CRM has remained committed to playing a leading national role in the development of Canadian Mathematics. This is reflected in the collaborative relations it has with the Fields Institute and PIms, with AARMS and CCARMS, with a number of universities and with various Canadian Associations, and professional societies. The coming year will see critical decisions being made for the future of Mathematical Sciences in Canada as the CRM and the other institutes seek refinancing in the framework of the reallocation exercise. A first step in this process has been the work of the Canadian Mathematics Review Committee whose visit in Quebec was steered by the CRM. In this context, I trust that the present report clearly illustrates how cost-efficient the CRM is. What this institute accomplishes with the level of funding it gets is remarkable. Yet this level is not optimal. For instance, let us consider the situation with postdoctoral fellowships. Thanks to collaboration with the ISM, the **nc***m*$_2$ research centres and contributions from its members, the CRM could count some twenty-two postdoctoral fellows in residence in 1996-1997. This is far from sufficient however for an institute of its calibre. In the same vein, there should be more funds to support long-term visitors — the return would be enormous.

The past twenty-eight years have shown how great a vehicle the CRM is for the development of science in Canada. It owes its success to the goodwill and the generosity of the many who contributed in one way or another to its activities, and I wish to thank them again warmly. I also take the occasion to acknowledge the continued support of our contributors, in particular NSERC, the Université de Montréal, FCAR, the Canadian Institute for Advanced Research and the André and Nussia Aisenstadt Foundation. With the growing importance of knowledge in the global economy, it is clear that the CRM has the potential to play in the future an expanded strategic role in R & D. I trust that this, as well as its essential role in the promotion of research in mathematics in Canada, will be recognized more and more.

Luc Vinet, Director

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PRESENTING THE CRM

The Centre de recherches mathématiques (CRM) was created in 1969 by the Université de Montréal through a special grant from the NRC. It became an NSERC national research centre in 1984. It is currently funded by NSERC (Natural Sciences and Engineering Research Council), by the Government of Québec through the Fonds FCAR pour l'aide et le soutien à la recherche and the Université de Montréal, and by private donations. The mission of the CRM is to do research in mathematics and closely related disciplines and to provide leadership in the development of the mathematical sciences in Canada.

The CRM accomplishes its mission in several ways. As part of its national mandate,

- it organizes a series of scientific events each year, around a given theme (distinguished lecture series, workshops, conferences, summer schools, visitor programs, etc.);
- it has a general program which helps to fund conferences and special events across the country;
- each year it invites, through the Chaire Aisenstadt, one or two prestigious mathematicians to give advanced courses, as part of its thematic program;
- it awards three prizes yearly: the CRM-Fields Prize recognizing major contributions to mathematics, the Aisenstadt Prize given for outstanding work done by a young Canadian mathematician, and the CAP-CRM Prize for exceptional achievement in theoretical and mathematical physics;
- it publishes some 150 technical reports and about 6-8 books per year. Some of its collections are published jointly with the AMS and with Springer Verlag;
- it has an extensive postdoctoral fellowships program, with 22 postdoctoral fellows in place last year, funded either solely by the CRM or in partnership with other organisations;
- it informs the community of its activities through its web site at **`www.CRM.UMontreal.CA`**.

This national mandate is complemented by, and indeed supported by, a long standing vocation of promoting research in the Montréal area. Indeed the CRM

- supports, through partnership agreements, a local group of researchers chosen mainly from departments of mathematics and statistics, but also from departments of computer science, physics, economics, engineering, etc.;
- works actively at developing contacts with industry. Its joint activities with liaison and research centres (CERCA and CIRANO) and research centres doing applied research (CRT and GERAD) has led to the creation, this year, of the Network for Computing and Mathematical Modelling (**ncm_2**). This network is funded by NSERC and 19 partners such as financial institutions, high-tech companies and ministries.

The CRM fulfils its national mission by involving the largest possible number of Canadian mathematicians in its scientific programs, both as participants and as organizers. It also supports many events taking place outside Montréal and the Province of Québec. It is recognized worldwide as one of the major institutes in the mathematical sciences. The director of the CRM is supported by two managerial structures: the Bureau and the Advisory Committee. The Advisory Committee is a prestigious group of internationally renowned mathematicians, both Canadian and non-Canadian, who approve scientific programs and thematic years, choose recipients of the CRM-Fields and Aisenstadt prizes, and suggest new scientific ventures to explore. The president of the Canadian Mathematical Society is a member ex officio. This structure is augmented by the CRM-Fields committee that oversees the collaboration and coordination between the two institutes and assures the truly national role of both. The members are representatives of the Canadian scientific community.

PERSONNEL

THE DIRECTOR'S OFFICE

Luc VINET	*Director*
Martin GOLDSTEIN	*Deputy Director*
Yvan SAINT-AUBIN	*Deputy Director*
Diane POULIN	*Secretary*

ADMINISTRATION

Ghislain GIROUX-DUFORT	*Head of Administration*
Michèle GILBERT	*Secretary*
Isabelle SÉGUIN	*Secretary*

SCIENTIFIC ACTIVITIES

Louis PELLETIER	*Coordinator*
Josée LAFERRIÈRE	*Assistant Coordinator*
Diane BRULÉ-DE FILIPPIS	*Secretary*

PUBLICATIONS

André MONTPETIT	*TeX Expert*
Louise LETENDRE	*Technician*

COMPUTER SERVICES

Daniel OUIMET	*UNIX Systems Manager*
David RAND	*Web & Macintosh Expert*

SCIENTIFIC PERSONNEL

Since its foundation in 1969, the CRM has supported a wide variety of research in mathematics by having various members attached to it, either as research staff, or through exchange agreements with neighbouring universities and industries, or as long-term visitors. These people perform their research at the CRM, and their presence has brought many benefits. In particular, the CRM's national program is greatly facilitated by having on hand a large reserve of willing organisers, who have even contributed financially to the organisation of activities. The largest partnership is with the Université de Montréal, which gives annually the equivalent of 6 full-time teaching positions in release time to the CRM. The CRM has release agreements with the other Montréal area universities, providing for the equivalent of two more full time positions. Facilities are also provided to researchers attached to junior colleges. In addition, each year, a certain number of visiting researchers spend the year at the CRM and are given visiting member status. There are also members whose presence is due to industrial agreements with Atlantic Nuclear Services and Lockheed Martin.

Members

Ali, Syed Twareque	Dept. of Math. and Stat., Concordia Univ.
Arminjon, Paul	Dép. de math. et de stat., Univ. de Montréal
Beaulieu, Liliane	Collège de Rosemont
Bélair, Jacques	Dép. de math. et de stat., Univ. de Montréal
Bengio, Yoshua	Dép. d'info. et de rech. op., Univ. de Montréal
Bergeron, Nantel	York Univ.
Broer, Abraham	Dép. de math. et de stat., Univ. de Montréal
Clarke, Francis	Dép. de math. et de stat., Univ. de Montréal
Delfour, Michel	Dép. de math. et de stat., Univ. de Montréal
Durand, Stéphane	Collège Édouard-Montpetit
Fleischer, Isidore	Fleischer Foundation
Fournier, Richard	Collège Dawson
Frappat, Luc	CNRS, LAPP
Frigon, Marlène	Dép. de math. et de stat., Univ. de Montréal
Gagnon, Langis	Lockheed Martin Canada
Goulard, Bernard	Dép. de physique, Univ. de Montréal
Granas, Andrzej	Dép. de math. et de stat., Univ. de Montréal and Univ. Nicolas Copernicus
Grundland, Michel	Dép. de math., Univ. du Québec à Trois-Rivières
Hahn, Geňa	Dép. d'info. et de rech. op., Univ. de Montréal
Harnad, John	Dept. of Math. and Stat., Concordia Univ.
Hurtubise, Jacques	Dept. of Math. and Stat., McGill Univ.
Hussin, Véronique	Dép. de math. et de stat., Univ. de Montréal
Kamran, Niky	Dept. of Math. and Stat., McGill Univ.
Kharlampovich, Olga	McGill Univ.
Kirillov, Anatoli	Steklov Mathematical Institute
Labelle, Gilbert	Univ. du Québec à Montréal
Langlands, Robert	Institute for Advanced Study
Léger, Christian	Dép. de math. et de stat., Univ. de Montréal
Leroux, Pierre	Univ. du Québec à Montréal
Lessard, Sabin	Dép. de math. et de stat., Univ. de Montréal
LeTourneux, Jean	Dép. de physique, Univ. de Montréal
Lina, Jean-Marc	Atlantic Nuclear Services Ltd.
Mayrand, Michel	Lockheed Martin Canada
McKay, John	Concordia Univ.
Patera, Jiří	Dép. de math. et de stat., Univ. de Montréal
Rahman, Q.I.	Dép. de math. et de stat., Univ. de Montréal
Rosenberg, Ivo	Dép. de math. et de stat., Univ. de Montréal
Rousseau, Christiane	Dép. de math. et de stat., Univ. de Montréal

Roy, Roch	Dép. de math. et de stat., Univ. de Montréal
Sabidussi, Gert	Dép. de math. et de stat., Univ. de Montréal
Saint-Aubin, Yvan	Dép. de math. et de stat., Univ. de Montréal
Sankoff, David	Dép. de math. et de stat., Univ. de Montréal
Schlomiuk, Dana	Dép. de math. et de stat., Univ. de Montréal
Shahbazian, Elisa	Lockheed Martin Canada
Sharp, Robert	Dept. of Physics, McGill Univ.
Soumis, François	GERAD
Stern, Ron	Dept. of Math. and Stat., Concordia Univ.
Turgeon, Jean	Dép. de math. et de stat., Univ. de Montréal
Valin, Pierre	Lockheed Martin Canada
Van Vliet, Carolyne	Coll. of Eng. and Design, Florida International Univ.
Vinet, Luc	Dép. de physique, Univ. de Montréal
Winternitz, Pavel	Dép. de math. et de stat., Univ. de Montréal
Yatracos, Yannis G.	Dép. de math. et de stat., Univ. de Montréal
Zolésio, Jean-Paul	Institut Non Linéaire de Nice

Postdoctoral Fellows

The CRM receives each year several postdoctoral fellows. The source of their funding can be a national program like the NSERC postdoctoral program, the NATO international program administered by NSERC, the CRM (alone or with the ISM or the Fields Institute) or personal grants from the members. Since 1993-1994 we have added to this list the CRM industrial program, allowing us to offer industrial fellowships in collaboration with our partners CERCA, GERAD and Lab CFD Concordia.

Ben Slimane, Mourad	École Nationale des Ponts et Chaussées
Bracken, Paul	Univ. of Waterloo
Bykov, Nikolay	Weizman Institute of Science (CRM-ISM)
de Guise, Hubert	Univ. of Toronto
Ferretti, Vincent	Univ. de Montréal
Hu, Ying	Wuhan Univ.
Jurčo, Branislav	Palacky Univ.
Kallel, Sadok	Univ. of British Columbia
Kasman, Alex	Univ. of Boston
Lamontagne, François	SUNY at Stony Brook
Li, Xiaochun	Univ. of British Columbia (CRM-ISM)
Makar-Limanov, Sergei	Univ. of Stanford (CRM-ISM)
Orlov, Aleksander	Landau Institute, Moscou
Papageorgiou, Yannis	Yale Univ. (CRM-ISM)
Spiridonov, Vyacheslav	Moscow State Univ.
van Diejen, Jan Felipe	Univ. of Amsterdam (CRM-ISM)
Zadra, Ayrton	Universidade de São Paulo

Industrial Postdoctoral Fellows

Dompierre, Julien	École Centrale de Paris (CRM-Lab CFD Concordia)
Gamache, Michel	École Polytechnique de Montréal (CRM-GERAD)
Lin, Fangbiao	Iowa Institute of Hydraulic Research (CRM-CERCA)
Yang, Geng	Univ. Laval (CRM-CERCA)
Yu, Wei	Univ. Blaise-Pascal (CRM-CERCA)

Visitors

The CRM receives each year a large number of visitors. Most of these are here to participate in scientific activities: in the year 1996-97, 545 participants registered for workshops run solely by the CRM. In addition, the CRM helped fund 10 other scientific events. The following list does not include any of these, but only those who visited for longer periods, ranging from over a week to several months.

Alspach, Brian R.	Simon Fraser University
Babai, László	University of Chicago
Bergeron, Nantel	York University
Byrnes, James S.	Prometheus Inc.
Cipu, Mihael	Concordia University
Conte, Robert	CEA - Saclay
D'Hoker, Eric	University of California, Los Angeles
Dubois, Sylvie	Louisiana State University
Duneau, Michel	École Polytechnique (France)
Exner, Pavel	University of Prague
Flaschka, Hermann	University of Arizona
Fleischer, Isidore	Fleischer Foundation
Floreanini, Roberto	Instituto Nazionale di Fisica Nucleare
Fradkin, Michael A.	Laboratoire Léon Brillouin, CEA Saclay
Garsia, Adriano M.	University of San Diego
Gazeau, Jean-Pierre	Université de Paris VII
Grimm, Stefan	Universität Basel
Havlicek, Miloslav	Faculty of Nuclear Sc. and Physics Eng. (Czech Republic)
Hereman, Willy	Colorado School of Mines
Hernandez Heredero, Rafael	Universidad Complutense de Madrid
Jiang, Zhuhan	University of New England
Kececioglu, John	University of California, Davis
Kooij, Robert	University of North Carolina
Lakshmikantham, Val	Florida Institute of Technology
Ledyaev, Yuri	Rutgers University
Leng, Xiaodan	University of California
Levi, Decio	Università di Roma
Liriano, Sal	City College
Masáková, Zuzana	Faculty of Nuclear Sc. and Physics Eng. (Czech Republic)
Michel, Louis	IHES, France
Morris, Joy	Simon Fraser University
Novikov, Dmitry	Weizmann Institute of Science
Pogosyan, Georges	Joint Inst. for Nuclear Research (Dubna)
Raoult, Annie	Université Joseph-Fourier
Rideau, Guy	Université Paris VII
Roussarie, Robert	Université de Bourgogne
Rowe, David	University of Toronto
Ruijsenaars, Simon	Centrum voor Wiskunde & Informatica (CWI)
Schupp, Peter	University of Munich
Sheftel, Misha B.	North-Western Correspondence Polytechnical Institute (St. Petersburg, Russia)
Siran, Josef	Slovak Technical University
Sudbery, Tony	University of York
Tolar, Jiří	Czech Technical University
Vinter, Richard B.	Imperial College of London
Wolenski, Peter	Louisiana State University
Yakovenko, Sergey	Wiezman Institute of Science
Zelmanov, Efim	Yale University
Zhedanov, Alexei	Donetsk University

MANAGEMENT

Bureau

The Bureau consists of members from the Université de Montréal (8 to 11 members) and from the outside (2 to 5 members). The rector of the Université and the dean of the Faculté des arts et des sciences are represented on the Bureau. Its role is to adopt the policies of the Centre, to recommend the nomination and the promotion of researchers and the appointment of regular members, to advise the director on the preparation of the budget and the Université on the choice of the director.

Bédard, Robert	Dép. de math. et de stat., Univ. du Québec à Montréal
Goldstein, Martin	Deputy Director, Centre de recherches mathématiques
Harnad, John	Dép. de math. et de stat., Concordia Univ.
Hubert, Joseph	Vice-doyen à la recherche, Faculté des arts et des sciences
Hussin, Véronique	Dép. de math. et de stat., Univ. de Montréal
Kamran, Niky	Dép. de math. et de stat., McGill Univ.
L'Écuyer, Pierre	Dép. d'informatique et de recherche opérationnelle., Univ. de Montréal
Legendre, Pierre	Dép. des sciences biologiques, Univ. de Montréal
Michaud, Georges	Director, CERCA
Montmarquette, Claude	Director, Dép. des sciences économiques, Univ. de Montréal
Moore, Marc	Dép. de math. et de génie industriel, École polytechnique de Montréal
Rousseau, Christiane	Director, Dép. de math. et de stat., Univ. de Montréal
St-Jacques, Maurice	Vice-recteur à la recherche et à la planification, Univ. de Montréal
Vinet, Luc	Director, Centre de recherches mathématiques

Advisory Committee

The Advisory Committee is constituted of distinguished researchers from Canada and abroad. Its members are either mathematicians or scientists with close ties to the mathematical sciences. The rector of the Université de Montréal or his representative and the director of the CRM also take part in the meetings. The Advisory Committee is informed periodically of the activities of the Centre, through the director, and transmits any advice that it deems relevant to the Bureau.

Dawson, Donald	Dept. of Math. and Stat., Carleton Univ.
Fillmore, Peter A.	Dalhousie Univ.
Goldstein, Martin	Deputy Director, Centre de recherches mathématiques
Heinrich, Katherine	Dept. of Math. and Stat., Simon Fraser Univ.
Kahane, Jean-Pierre	Univ. de Paris XI, France
Kisilevsky, Hershy	Dept. of Math., Concordia Univ.
Lalonde, François	Dép. de math. et d'informatique, Univ. du Québec à Montréal
Manin, Yuri	Max-Planck-Institut für Mathematik, Germany
Moody, Robert V.	Dept. of Math., Univ. of Alberta
Moser, Jürgen K.	Dept. of Math., E.T.H., Switzerland
Phong, Duong H.	Dept. of Math., Columbia Univ.
Reid, Nancy	Dept. of Stat., Univ. of Toronto
Vinet, Luc	Director, Centre de recherches mathématiques

CRM/Fields Committee

According to the guidelines which NSERC's Committee on Collaborative Special Projects (CCSP) sent to the CRM and the Fields Institute after the review of their last application in 1994, the mandate of the CRM-Fields Institute Coordinating Committee is the following:
***(i)* monitor the national impact of the CRM and the Fields Institute as research resources in the Mathematical Sciences and**
***(ii)* monitor and facilitate the coordination of activities between the two centres.**
The members of the CRM-FI Coordinating Committee are:

M. Boyer	CIRANO, Montréal
H. Brunner	Chair, Memorial Univ.
J. B. Friedlander	Univ. of Toronto
P. Goddard	Cambridge Univ., UK
M. Moore	École Polytechnique, Montréal
D. Rolfsen	Univ. of British Columbia
J. Slonim	IBM Centre for Advanced Study, Toronto
J. G. Timourian	Univ. of Alberta
H. C. Williams	Univ. of Manitoba

Computer Facilities

The CRM offers to its members and visitors a Unix environment based on a SUN Sparc 1000 equipped with eight 50-Mhz processors and 384 Mb of memory. This computing power is distributed through the offices and common rooms via Sun stations (from Sparc 4, 5 and 10 to Ultra) and X-terminals. The software libraries include compilers (several C and C++, Fortran, etc.), symbolic manipulation programs (Mathematica, Maple and Macaulay), several text editors, web browsers, mail tools, and most utilities common to the mathematical world. Upgrades to TeX and its dialects are uploaded whenever they are released.

The CRM also has a Silicon Graphics Challenge L with six R4400 processors at 100 Mhz and 128 Mb of memory that was purchased through the NSERC grant of one of its research teams. Access to this server is limited to the members of the team or, upon request, to other members with numerical processing needs.

The local net is linked to the network of the Université de Montréal that maintains the connections with RISQ (Réseau interordinateurs scientifique québécois) and CA*net (the Canadian internet transit service).

The support staff works on Sun stations, on X-terminals or on Macintoshes tied to the Sun server for mail services and back-ups.

SCIENTIFIC ACTIVITIES

The core of each year's scientific program at the CRM is its thematic program. The topic is chosen by the Advisory Committee for its scientific importance, its timeliness, and its impact on the Canadian scientific community. Preceeding years' topics include: Probability and Stochastic Control (1992-93); Dynamical Systems (1993-94); Geometry and Topology (1994-95); and Applied and Numerical Analysis (1995-96). A year's activities can combine a good number of workshops and conferences, one or two Aisenstadt chairs, a certain number of visiting scientists in residence, and some post-doctoral fellowships. Typically, there is some coordination with Montréal universities to offer appropriate graduate courses in order to help graduate students participate in the activities.

Theme Year 1996-1997: Combinatorics and Group Theory

Overview

The theme of the 1996 -1997 academic year at the CRM was Combinatorics and Group Theory. Combinatorics is a subject whose importance has grown tremendously in recent years, reflecting its enormous importance in many concrete problems either of computer science and operations research. The thematic program covered a wide variety of areas, including graph theory, with a special session on colouring problems, combinatorial designs, algebraic combinatorics, and "experimental mathematics." The activities in combinatorics were combined with a program in related subjects in group theory such as hyperbolic and automatic groups, actions on trees, and combinatorial group theory.

The holders of the Chaire Aisenstadt for the year were László Babai of Eötvos University and the University of Chicago, and Efim Zelmanov of Yale University.

The scientific events are described below. They took place at the CRM unless specified otherwise.

Pseudorandom Number Generation

3-21 June 1996

Org.: G. Brassard (Montréal), C. Crépeau (Montréal), R. Couture (Montréal), P. L'Écuyer (Montréal), H. Niederreiter (Austrian Academy of Sciences)

The main objective of this workshop was to bring together researchers studying the generation of pseudorandom numbers from various backgrounds: number theorists, physicists who use billions of random numbers in their stochastic simulations and who need fast and reliable generators, cryptologists for whom unpredictability is crucial, statisticians interested in faithful simulations of probabilistic laws of stochastic processes in order to estimate their properties, hackers who discover faults in certain generators, and finally computer scientists who try to implement fast and reliable generators that can satisfy everybody.

Participants came from Asia, Europe and North America. The presence of internationally renowned researchers, like H. Niederreiter and I. Sobol', attracted many first class scientists.

The program was divided into 3 topics, 1 per week:

1. Characteristics required from good generators. Criteria of selection and statistical tests.
2. Linear methods.
3. Nonlinear and cryptographic methods. Software implementation.

An average of two one-hour lectures were given each day, followed by long periods of questions, discussions and comments. This allowed for informal discussions and more collaborations were started here than in usual conferences. Participants reacted very positively to this new format and said that they learned a lot from the wide spectrum of specialists present.

No proceedings were supposed to be published. However a special issue of the quarterly journal ACM Transactions on Modelling and Computer Simulation will be devoted to the subjects covered at the workshop. The invited editors are R. Couture and P. L'Écuyer, two of the organizers.

CRM Summer School on Group Theory

Banff Centre of Arts, Banff, Alberta
11-23 August 1996
Org.: G. Baumslag (CUNY), D. Gildenhuys (McGill), O. Kharlampovich (McGill), E. Zelmanov (Yale)

The summer school was primarily aimed at PhD students in their final years and recent Ph.D.'s. Its main objective was to prepare people for the workshops that were to follow. About 35 students were selected from over 70 applicants. They came from Canada, USA and France.

The following short courses were given:

- Basic combinatorial group theory (Gilbert Baumslag)
- Connections between groups and Lie algebras (E. Zelmanov)
- Hyperbolic and automatic groups (S. Gersten)
- Introduction to pro-p-groups; analytic pro-p-groups (Marcus du Sautoy)
- Algebraic topology, fundamental groups, covering spaces (N. Benakli)
- Simplicial trees and length functions (Ian Chiswell)
- Van Kampen diagrams (Sergey Ivanov)
- Algorithmic problems (M. Sapir, O. Kharlampovich)
- Algebraic geometry over groups (A. Myasnikov)
- Homological methods in groups (Yu. Kuz'min)
- Identities of representations of finite groups (S. Vovsi)

The proceedings of the Summer School are to be published in a volume of the CRM Conference Proceedings. Invited speakers have submitted short surveys for publication. All submissions have been refereed. O. Kharlampovich is editing the Proceedings.

Cayley Graphs

16-20 September 1996
Org.: G. Hahn and G. Sabidussi (U. de Montréal)
Invited speakers: B. Alspach, L. Babai, P. Cameron, D. J. Dunwoody, W. Imrich, S. Klavzar , D. Marusic, N. Seifter, J. Širáň, V. Trofimov, M. E. Watkins

There were thirty-three participants ranging from invited speakers (fifteen) to students. They came from all over the world — Austria, Canada, Great Britain, Slovakia, Slovenia, United States, to name but the countries of the invited speakers. The group spent the week listening to lectures on recent advances in the theory of Cayley graphs, lectures given by recognized experts as well as by doctoral students. Both finite and infinite graphs and groups were covered in presentations on various subjects. One of the attractions of the workshop was a series of lectures by László Babai on **Combinatorial Properties of Vertex-Transitive Graphs**.

The invited talks included topics such as:

- Subgraphs of Cayley graphs (Alspach),
- Factoring cardinal product graphs in polynomial time (Imrich),
- Half-transitive graphs (Marušič),
- Cayley representations of infinite edge-transitive planar graphs (Watkins),
- Homomorphisms and graph products (Klavžar),
- Cayley maps (Širáň),
- Graphs with polynomial growth (Seifter),
- Vertex-symmetric graphs and Cayley graphs (Trofimov),
- Highly symmetric countable graphs as Cayley graphs (Cameron),
- Ends of pairs of groups and the Jaco-Shalen-Johannson decomposition for finitely presented groups (Dunwoody).

The presence of computer scientists should be noted. Indeed, Cayley graphs are studied more and more in computer science and so old results are of interest there, while new problems interesting to mathematicians are suggested.

Combinatorics of Words

1 - 5 October 1996, UQAM (Université du Québec à Montréal)
Org.: Sre ko Brlek

The goal of this meeting was twofold. First it aimed at providing an overview of algorithmic problems arising naturally in the study of words based on a finite alphabet. These cover both statistical aspects (computation of complexity measurements) and structural problems (the search for patterns, motives, particular structures). The second aim was to fill the pressing need for the development of formal computational tools adapted to word combinatorics.

The meeting drew around twenty participants, as well as ten students and professors of the LaCIM (UQAM). The speakers were Jean Paul Allouche (LRI, Orsay), Valérie Berthé (IML, Marseille), Julien Cassaigne (IML, Marseille), Michel Koskas (LARIA, Amiens) as well as Dominique Bernardi (TNAD, Paris VI), Srečko Brlek, Annie Ladouceur and Christophe Reutenauer (LaCIM).

All the lectures were tied to the theme of word complexity. Some combinatorial problems relating the measurements of recursion with complexity were first discussed. Then the particular case of infinite words obtained by rotations of the unit circle was considered. A third lecture developed Cassaigne's fine techniques for fixing bounds on complexity measurements. Finally a review of the links between automatic sequences and the questions of transcendence in number theory was presented.

On October 3rd, a long-term cooperation plan was drawn up by Dominique Bernardi, Srečko Brlek, Julien Cassaigne, Michel Koskas and Annie Ladouceur to develop a formal computational tool adapted for word combinatorics. Several questions were addressed concerning this project:

(i) Scientific design: algorithms for the construction of infinite words, computation on words, identification of combinatorial properties, functions related to factors of infinite words;

(ii) Technical design: development language (C++), data bases for primitives, interfaces with other existing tools;

(iii) Administrative structure: constitution of the development group CABAC, computer tools, sharing of the central directory at LaCIM. The persons responsible were unanimously chosen as Sreãko Brlek (scientific and administrative management) and Annie Ladouceur (development management). Funding will be sought from the Programmes France-Québec. First contacts have already been established with the funding agencies.

(iv) Future ventures: the meeting succeeded in creating a network of researchers sharing the goal of developing a formal computational tool in word combinatorics. The teams involved are the LRI (Orsay), the IML (Marseille), the TNAD (Paris), the LARIA (Amiens) and the LaCIM (Montréal). The network hopes to have a working prototype available by June 1997. Visits are already scheduled: Koskas (February 1997) and Cassaigne (May 1997) at the LaCIM, Brlek at the LRI (Allouche) and at the IML (Cassaigne and Berthe) and Ladouceur at the LARIA and the LRI. Other meetings have been planned but no dates have been fixed as of now.

Hyperbolic and Automatic Groups; Groups Acting on R-Trees

13-19 October 1996

Org.: G. Baumslag (CUNY), D. Gildenhuys (McGill), O. Kharlampovich (McGill), E. Zelmanov (Yale)

The purpose of the workshop was to bring together specialists approaching group theory from different angles.

One of these is the geometric approach. Much of combinatorial group theory has its roots in geometrical and topological ideas. For example, the notion of non-positive curvature, implicitly underlying small-cancellation theory, has been abstracted and exploited by Gromov, Cannon and Rips, among others, resulting in a sizable body of work on hyperbolic (or negatively curved) groups. This work has many links to other areas like hyperbolic metric spaces, hyperbolic manifolds and group actions on *R*–trees. In this context, we should mention as well the geometric methods based upon Van Kampen diagrams. These methods were substantially developed by Ol'shanskii in his work on the Burnside, and related, problems.

A second approach is via logical methods. The area of algorithmic solvability of problems in group theory fall under this heading. Razborov (1990 Nevanlinna prize winner) has constructed an algorithm which recognizes the solvability, or otherwise, of a system of equations over a free group. His construction uses ideas due to Makanin. The same ideas turned out to be very fruitful in many other investigations, in particular in Rips' solution of the Morgan-Shalen conjecture about groups acting on *R*-trees.

A third approach to combinatorial group theory has its roots in the Bass-Serre theory of groups acting on trees.

The list of invited speakers included M. Bestvina, M. Bridson, N. Brady, T. Delzant, S. Gersten, G. Levitt, O. Kharlampovich, L. Mosher, A. Myasnikov, A. Ol'shanskii, E. Rips, Z. Sela, M. Staretz.

Distance-Regular Graphs

18-23 November 1996

Org.: G. Hahn and G. Sabidussi (U. de Montréal)
Invited speakers: E. Bannai, N. Biggs, A. E. Brouwer, P. Cameron, A. Cohen, A. D. Gardiner, C. Godsil, A. A. Ivanov, L. K. Jørgensen, M. Mulder, P. Terwilliger

The workshop attracted thirty-nine participants, including many students. As with the workshop on

Cayley graphs, the pleasure of being with like-minded souls showed. László Babai continued his lectures, this time on **Algorithms in Finite Groups**, while the other participants (again, from students to well-known experts) discussed the various aspects of classifying distance-regular and distance-transitive graphs.

The invited talks included topics such as:

- primitivity in commutative association schemes (Terwilliger),
- primitive symmetric association schemes with $m_1 = 3$ (Bannai),
- the classification of distance-regular graphs of valency four (Brouwer),
- almost distance-regular graphs (Mulder),
- progress in the classification of distance-regular graphs (Cohen),
- affine distance-transitive graphs with sporadic vertex stabilizer (Ivanov),
- potential theory and distance-regular graphs (Biggs),
- directed strongly regular graphs (Jørgensen),
- census of infinite distance-transitive graphs (Cameron),
- revisiting distance-biregular graphs (Gardiner),
- eigenpolytopes of distance-regular graphs (Godsil).

Both the workshop on Cayley graphs and the present one included a problem session, and a list of problems from these was sent, after editing, to all participants.

General Combinatorial Group Theory

5-11 April 1997

Org.: G. Baumslag (CUNY), D. Gildenhuys (McGill), O. Kharlampovich (McGill), E. Zelmanov (Yale)

The workshop included a wide variety of topics. The list of invited talks included the following.

- G. Baumslag: *Wreath products and groups of Type FP(2).*
- R. Gilman: *Groups and Formal Languages.*
- R. Grigorchuk: *Investigation of Slavonic automatic groups.*
- L. Ribes: *Profinite methods in groups.*
- O. Kharlampovich, A. Myasnikov: *Description of finitely generated fully residually free groups.*
- V. Remeslennikov: *Algebraic geometry over groups close to free groups.*
- J. Labute: *Lie algebras and central series of groups.*
- A. Juhats: *Extensions of group presentations and relative small cancellation theory.*
- A. Krasilnikov: *Solvable varieties of groups: the finite basis problem.*
- A. Lubotzky:
  1. *Property t and its group theoretic applications.*
  2. *Subgroup growth and normal subgroup growth.*
- M. du Sautoy: *Zeta functions as invariants for infinite groups.*
- J. McCool: *Presenting $GL_n(RG)$.*
- M. Sapir: *Length and area distortions and Dehn functions in groups.*
- A. Schmel'kin: *On automorphisms of groups of type F/R', where F is a free group or free product.*

There were also some contributed talks.

Transversal Designs and Orthogonal Arrays

21-25 April 1997, Four Points Hotel, Kitchener, Ont.

Org.: Charles Colbourn (Waterloo), Ron Mullin (Waterloo), Alex Rosa (McMaster), Doug Stinson (Nebraska at Lincoln)

The workshop on transversal designs and orthogonal arrays was designed to bring together researchers on combinatorial, algebraic, statistical, and coding theoretic aspects of orthogonal arrays; to focus on applications; and to involve graduate students and beginning researchers. The format of the workshop involved one plenary (one hour) speaker each day, providing a quite comprehensive overview of the main research directions. Kathy Heinrich and Charlie Colbourn presented plenary talks focusing on the use of orthogonal arrays in construction of block designs and related designs. Alex Pott introduced the connections with geometry, number theory, and algebra in the context of difference sets. Neil Sloane described connections with coding theory, particularly with an important new application in numerical finance. Debbie Street described connections with experimental design in statistics.

The plenary talks were well supplemented by both invited and contributed talks. Topics of the invited speakers (fifteen in all) were well distributed among the main research topics on orthogonal arrays. Applications of orthogonal arrays to the construction of *(t,m,s)*-nets for numerical integration problems, primarily in finance, arose as a theme in four of the talks. Other concentrations were on computational methods for construction of orthogonal arrays, covering arrays and their application in software testing, and to applications in coding theory and experimental design. The workshop's original plan to bring together

researchers from a variety of backgrounds paid excellent dividends, particularly in promoting applicable research.

The participation of younger researchers and graduate students through contributed talks, and informal discussions, was also most encouraging. Twelve graduate students participated, among a total of sixty participants (approximately as expected).

The program of talks was very well received. In addition, participants were very positive about the idea of organizing a conference around the theme of a central combinatorial structure but including statisticians, coding theorists, computer scientists, and others. While all of the participants spoke about the same underlying mathematical object, their particular emphases provided a valuable synergy.

A number of research directions were advanced as a result of the interaction at the workshop, including research on *(t,m,s)*-nets, on covering arrays and software testing, on difference sets, on pairwise balanced designs, and on computational methods. Collaborations begun at the workshop are already bearing fruit.

The workshop was both productive and enjoyable for the participants, and fulfilled its main objectives in bringing together researchers from a variety of backgrounds, and in exposing graduate students and young researchers to a challenging and diverse topic.

The keynote speakers were: Charlie Colbourn (Univ. of Vermont), Katherine Heinrich (Simon Fraser Univ.), Alexander Pott (Univ. Augsburg), Neil Sloane (AT&T Labs, Murray Hill), Deborah Street (Univ. of Technology, Sydney).

The invited speakers were: Julian Abel (Univ. New South Wales), Frank Bennett (Mount St. Vincent Univ.), Jurgen Bierbrauer (Michigan Technological Univ.), Art Drisko (U. S. Dept. of Defense), Dieter Gronau (Univ. Rostock), Donald Kreher (Michigan Technological Univ.), Chuck Laywine (Brock Univ.), Gary Mullen (Pennsylvania State Univ.), Kevin Phelps (Auburn Univ.), Douglas Stinson (Univ. of Manitoba), Luc Teirlinck (Auburn Univ.), Vladimir Tonchev (Michigan Technological Univ.), John van Rees (Univ. of Manitoba), Mieczyslaw Wojtas (Technical Univ. of Wroclaw), Jeff Wu (Univ. of Michigan).

Graph Colouring and Applications

5-9 May 1997, CRM
Sponsors: CRM, GERAD (Groupe d'études et de recherche en analyse des décisions)
Org.: Pierre Hansen, Odile Marcotte

This workshop brought together outstanding researchers in the fields of combinatorial optimization and graph theory. It consisted of eleven lectures by invited speakers and seventeen contributed talks. The opening lecture was given by Paul Seymour, from the mathematics department of Princeton University, who presented the latest and most elegant proof of the famous four-colour theorem. This proof is the result of work carried out by Paul Seymour himself and his collaborators, several of whom were also attending the workshop. The lecture of Professor Carsten Thomassen, from the Technical University of Denmark, had a similar topic, i.e., algorithms for colouring graphs embedded in specific surfaces. Professors Claude Berge (from Paris) and Vasek Chvátal (from Rutgers University) gave lectures on perfect graphs, a topic closely related to the vertex-colouring problem. Professor Anthony Hilton (from Reading) lectured on total colourings of graphs, and Professor Adrian Bondy (from Lyon) lectured on the relationship between colourings and orientations of graphs.

Graph colouring has many applications, some of which arise from practical concerns and others from the natural or social sciences. Professor Horst Sachs (from the Technical University of Ilmenau, in Germany) presented results on invariant polynomials of polyhedra and their application to chemistry. Dominique de Werra (from the École Polytechnique Fédérale de Lausanne) gave a lecture on the application of graph colouring to the problem of register allocation, which arises during the compilation of computer programs. Fred Roberts (from Rutgers University) presented a variant of graph colouring used in the modelling of social roles, and related this concept to other important concepts in the mathematical models of the social sciences. Finally, Mike Carter (from the University of Toronto) and Bjarne Toft (from Odense University, in Denmark) lectured on applications of graph colouring to timetabling. The last main lecture was given by Bjarne Toft, who educated and entertained his audience by discussing the life and correspondence of Julius Petersen, who gave his name to the famous Petersen graph!

The themes of the contributed talks were similar to those of the main talks, and the workshop was at-

tended by 46 researchers from eight countries (Canada, United States, France, England, Germany, Denmark, Switzerland and Israel). The workshop met with great success, and the conference room was full until the end of the workshop, on Friday afternoon!

Workshop on Experimental Mathematics and Combinatorics

19-30 May 1997

Org.: FBergeron (UQAM), G. Labelle (UQAM), P. Leroux (UQAM)

Methods of formal calculus play an ever growing role in mathematics. This is particularly true in domains, like combinatorics, where mathematical experimentation is an integral part of the research process. The aim of this workshop was to do an overview of the development of the computerized research tools for mathematics and to work on the applications of the most recent methods, mainly in combinatorics.

The workshop was held over a period of two weeks, the first at the CRM, the second at the Laboratoire de combinatoire et d'informatique mathématique (LACIM, UQAM). The program consisted of invited lectures, communications, problem periods, a tutorial on the formal calculus software MAPLE and workshops on combinatorial modelisations with formal calculus.

The main themes of the workshop were:

- Methods to generate automatically identities between Euler sums, zeta functions and polylogarithms.
- Development of general theories in enumerative combinatorics (generating functions, species theory (Pólya/Joyal), asymptotics, object grammars, proofs of identities) and their use through algebraic formal calculus).
- Computational methods related to particular topics like: statistical mechanics, hypergeometric functions, determinant theory, binary expansions of certain constants.

Lectures:

- Jonathan Borwein, Simon Fraser Univ., "*Evaluations of multidimensional polylogarithmic sums: a compendium of results for arbitrary depths*" and "*Some highly computational problems concerning integer polynomials with small norms*"
- Philippe Flajolet, INRIA-Rocquencourt, "*Automatic Combinatorics*"
- Anthony John Guttmann, University of Melbourne, "*On the solvability of some problems in combinatorics and statistical mechanics*"
- Marko Petkovsek, University of Ljubljana, "*Determinants with factorial entries*"
- Bruno Salvy, INRIA-Rocquencourt, "*Euler Sums and Contour Integral Representations*"
- Dennis Stanton, University of Minnesota, "*Positivity conjectures and Andrew's identities*"
- Volker Strehl, University of Erlangen-Nuernberg, "*Combinatorial identities - some aspects, some applications*"
- Xavier Gérard Viennot, Université Bordeaux I, "*Couleur, expérimentation, combinatoire, aléatoire*"
- Doron Zeilberger, Temple University, "*Combinatorial Combinatorics*"

Communications

- Minh Hoang Ngoc, L.I.F.L. - URA 369 CNRS, "*Un algorithme pour engendrer les relations entre les sommes d'Euler/Zagier*"
- Petr Lisonek, Simon Fraser University, "*Counting Labelled and Unlabelled Dissections of Convex Polygons*"
- Miguel A. Mendez, IVIC, Venezuela, "*Enumeration of types of structures over digraphs*"
- Simon Plouffe, Wolfram Research Inc., "*On the computation of the n^{th} decimal digit of various numbers*"
- David M. Bradley, Simon Fraser University, "*Strange Hypergeometric Series Evaluations, Zeta Function Formulae, and Computer Assisted Discovery*"
- Helmut Prodinger, Technical University Wiednerm, Vienna, "*New enumeration results related to binary search trees*"
- Mihai Cipu and John McKay, C.I.C.M.A., Concordia University, "*Experiments with replicable functions*"
- Gert Almkvist, University of Lund, "*A 'metaphysical method' to find asymptotic formulas*"
- S. Grishechkeine, Moscou , "*DNA Fingerprinting*"

Workshops:

- Bruno Salvy and Philippe Flajolet, INRIA-Rocquencourt, "*Atelier MAPLE*" and "*Atelier de modélisation combinatoire et MAPLE*"
- Doron Zeilberger, Temple University, "*A tutorial on Shalosh B. Ekhad*"

Workshop on Algebraic Combinatorics

9-20 June 1997

Org.: F. Bergeron (UQAM), N. Bergeron (CRM & York Univ.), C. Reutenauer (UQAM)

The purpose of this workshop was to study interactions between algebraic combinatorics and symmetric functions, with a special emphasis on:

(i) descent algebra of Coxeter groups in relation to quasi-symmetric functions and noncommutative symmetric functions, and

(ii) doubly parametrised Macdonald *(q,t)*-symmetric functions, in relation to harmonics of reflection groups.

The first part of the workshop (9-13 June) was devoted to a few conferences by well-known specialists in the area. The format of the first part, one conference in the morning, one in the afternoon, was ideal for discussions and exchange of ideas. Indeed, many junior mathematicians took advantage of this time to discuss problems with the speakers and with the other participants of the conference. The second part (16-20 June) was devoted to communications, problem sessions, software demonstrations and small work groups. Both weeks were a great success in terms of participation, discussion and collaboration. There were 56 official participants from more than ten countries.

Here is a list of the invited speakers for the first week with the title of their talks:

- P. Diaconis (Cornell): *Random walks on buildings*
- A. Garsia (UCSD): *Lattice diagram polynomials and extended Pieri rules*
- I. Gessel (Brandeis): *Quasi-symmetric functions and noncommutative symmetric functions of type* B_n
- I. Goulden (Univ. of Waterloo): *Extensions of Hurwitz' result on transitive factorisations in the symmetric group*
- M. Haiman (UCSD): *Macdonald polynomials and Hilbert schemes*
- A. Lascoux (Marne-la-Vallée): *Charge and Hall-Littlewood functions*
- L. Solomon (Univ. of Wisconsin): *Representations of the symmetric inverse semigroup*
- R. P. Stanley (MIT): *Some equations in the symmetric group*
- J. YThibon (Marne-la-Vallée): *Noncommutative symmetric functions; a progress report*
- D. N. Verma (Bombay): *Towards classifying finite point-set configurations*

Most of these conferences triggered long discussions afterwards. We certainly missed the presence of I. G. Macdonald and C. Procesi who had to cancel their trip to Montréal at the last minute.

In the second week, communications were given by: G. Bhowmik (Univ. de Valenciennes), P. Cellini (Univ. di Padova), S. Hamel (UQAM), A. Joellenbeck (Univ. Kiel), C. Lenart (MIT), F. Patras (Nice), M. Schocker (Univ. Kiel), F. Sottile (Univ. of Toronto), G. Tesler (UCSD), S. van Willigenburg (St. Andrews). We had two problem sessions. During the first one, the whole period was dedicated to problems suggested by many participants. During the second period, we also had a software demonstration of ACE given by A. Lascoux. The rest of the time was devoted to work in small groups.

Chaire Aisenstadt

The Chaire Aisenstadt was endowed by Montréal philanthropist Dr. André Aisenstadt. Under its auspices, one or two distinguished mathematicians are invited each year for a period of at least one week, ideally one or two months. During their stay the lecturers present a series of courses on a specialized subject. They are also invited to prepare a monograph. At the request of Dr. Aisenstadt, the first of their lectures should be accessible to a wide audience. Previous holders of the Chaire Aisenstadt are: Marc Kac, Eduardo Zarantonello, Robert Hermann, Marcos Moshinsky, Sybren de Groot, Donald Knuth, Jacques-Louis Lions, R. Tyrell Rockafellar, Yuval Ne'eman, Gian-Carlo Rota, Laurent Schwartz, Gérard Debreu, Philip Holmes, Ronald Graham, Robert Langlands, Yuri Manin, Jerrold Marsden, Dan Voiculescu, James Arthur, Eugene B. Dynkin, David P. Ruelle, Robert Bryant, Blaine Lawson, Yves Meyer and Ioannis Karatzas. This year the Chaire was awarded to Professors László Babai and Efim I. Zelmanov.

Professor László Babai
University of Chicago

László Babai, Professor in the Departments of Mathematics and Computer Science of the University of Chicago, held the Aisenstadt Chair in the fall semester of 1996.

Professor Babai received his Diploma in Mathematics from Eötvos University in Budapest, Hungary and his Ph.D. from the Hungarian Academy of Sciences in 1984. Since then he has been a faculty member at the University of Chicago.

Professor Babai's research is in the fields of combinatorics, graph theory and groups, especially automorphism groups. He is the author of some 140 papers and has given numerous invited addresses. Among his honours are the Gödel Prize, the T. Szele Prize, awarded by the J. Bolyai Mathematical Society, and the Mathematical Prize of the Hungarian Mathematical Society.

During his visit to the CRM in the fall of 1996, Professor Babai gave a series of lectures on Algorithms in Finite Groups. In addition, he gave a public lecture entitled "Surprise Methods in Combinatorics." A book based on these lectures will be published by the American Mathematical Society in the CRM Monograph Series.

Surprise Methods in Combinatorics
Lecture and reception: 22 November 1996, CRM

Algorithms in Finite Groups
Three lectures: 18, 19 and 21 November 1996, CRM, in conjunction with the workshop on "Distance-Regular Graphs"

Professor Efim I. Zelmanov
Yale University

The Aisenstadt Chair was held during the winter semester of the 1996-1997 academic year by Professor Efim I. Zelmanov. Professor Zelmanov received the degrees of M. S. (1977) and Ph.D. (1980) at the Novosibirsk State University, and his Dr. at the Leningrad State University in 1985. After holding various positions at Institutes of Mathematics in the former Soviet Union, he emigrated to the United States in 1990 and was Professor at the University of Wisconsin, the University of Chicago, and Yale University where he currently teaches.

Professor Zelmanov has written more than 60 papers, given numerous invited addresses, and is the editor of 7 major journals in Algebra. His awards include the Fields Medal, awarded in 1994 for the solution of the Burnside Problem, and the Medal of the Collège de France.

During his visit to the CRM in the spring of 1997, Professor Zelmanov gave a public lecture entitled "An Overview of Abstract Algebra in the 20th Century." The lecture was video-taped and is currently available from Les Publications CRM. He also gave a series of lectures covering aspects of the Burnside Problem, groups with the Golod-Shafarevich property, and growth in groups and Lie algebras. An expanded version of these lectures will appear in the CRM Monograph Series published by the American Mathematical Society.

An overview of Abstract Algebra in the 20th Century
Lecture and reception: 9 May 1997, CRM

On the Burnside Problem
Two lectures: 12 and 13 May 1997, CRM

In 1902 W. Burnside formulated his famous problem. Let G be a finitely generated group. Suppose that there exists $n > 1$ such that $x^n = 1$ for an arbitrary element x from G. Does it make the group G finite? Professor Zelmanov discussed the history of this problem and its relations with ring theory, Lie algebras, profinite groups, combinatorics, logic.

Variations on the theme of Burnside
14 May 1997, CRM

Professor Zelmanov discussed some open problems from different areas of mathematics (algebraic geometry, topology, Galois theory, geometric group theory) that are related to the Burnside problem.

On groups with Golod-Shafarevich property
20 May 1997, CRM

In 1964 Golod and Shafarevich found a sufficient condition for a group presented by generators and relations to be infinite. In the same volume of Izvestia Shafarevich applied this criterion to the construction of an infinite tower of class fields while Golod constructed a counter example to the General Burnside Problem. Professor Zelmanov discussed some recent developments related to groups satisfying the Golod-Shafarevich criterion.

On Growth in Groups and Lie Algebras
21 May 1997, CRM

Professor Zelmanov discussed the notions of growth in Groups and Algebras (the latter known as Gelfand-Kirillov dimension) focusing on Lie algebras and superalgebras of growth 1. Such are, for example, affine Kac-Moody algebras and superconformal algebras.

General Program

The CRM's general program funds a wide variety of scientific events, both on-site and around the country. The program is quite flexible, to allow for opportunities as they arise. One new feature is that the CRM, along with the other Canadian Mathematics Institutes, has taken over the responsibility for funding conferences across Canada, following the cancellation of NSERC's conference grant program.

The year 1996-97 saw a remarkable variety of activities being funded, in areas such as number theory, mathematical physics, statistics, complex analysis, dynamical systems, algorithms in CFD, Hopf algebras, and operator theory. Two general meetings were also funded, as well as a summer school in Nonlinear Dynamics in Physiology and Medicine.

5th Conference of the Canadian Number Theory Association (CNTA-5)

17-22 August 1996, Carleton University, Ottawa
Org.: Henri Darmon (McGill Univ.), John B. Friedlander (Univ. of Toronto), Rajiv Gupta (UBC), James G. Huard (Canisius Coll.), Damien Roy (Univ. of Ottawa), Kenneth S. Williams (Carleton Univ.)

The Canadian Number Theory Association (CNTA) is an informal organization of Canadian number theorists, which was founded in 1987 with the expressed intention of enhancing and promoting both learning and research in number theory and its applications. It has organized four conferences (Banff 1988, UBC 1989, Queen's 1991 and Dalhousie 1994). All of these conferences have been acclaimed by the international number theory community as being among the most successful and fruitful of such meetings. The number theory community relies on these meetings to keep abreast of the latest developments in the field. The present conference continued this strong tradition. It focused on the following four areas of number theory: algebraic/computational number theory, analytic number theory, arithmetic algebraic geometry and elliptic curves, and diophantine problems. All of these areas have seen rapid and very deep development in recent years, and all have had a significant impact on real-life applications, for example, computational number theory on public-key cryptography. The scientific program consisted of 1 general public lecture (D. Boyd), 4 one-hour plenary lectures (W. D. Duke, C. Pomerance, K. A. Ribet, M. Waldschmidt), 27 forty-minute special session invited talks, and 71 twenty-minute contributed talks. There were 180 registered participants: 60 from Canada, 81 from USA, 29 from Europe, 7 from Asia, and 1 each from Africa, Australia and South America.

Extended and Quantum Algebras and their Applications to Physics

Sponsors: Nankai Institute of Mathematics (Tianjin) and the CRM
19-24 August 96, Tianjin (China)
Org.: Ge Mo-Lin (Nankai Institute), Yvan Saint-Aubin (CRM), Luc Vinet (CRM)

The goal of this meeting was to foster collaborations between mathematical physicists in China and in Canada. As both the Nankai Institute for Mathematics (Tianjin, China) and the Centre de recherches mathématiques have very active mathematical physics groups, they took the lead in organizing this joint meeting. This collaboration was part of a larger agreement, the 3x3 Consortium, between three Chinese universities (Beijing University, Tianjin University and Tsiang Hua University) and four Canadian ones (McGill University, University of British Columbia, Université de Montréal and University of Toronto) that aims at developing collaborations between the two countries in seven strategic domains, one of them being mathematics.

The meeting brought together physicists and mathematicians from China and Canada, but also from the Pacific Rim (mainly Japan) and from Europe.

The main lectures were:

- H. Awata (Univ. of Chicago): *The vertex operators of q-Virasoro algebra and their application to physics;*
- T. Gannon (York Univ.): *Drinfeld, CFT, and Galois action on knots and their invariants;*
- Ge Mo-Lin (Nankai Inst.): *Yangian in physics;*
- Gun X. W.
  Lax pair and boundary r-matrix for 1-d Hubbard model;
- K. Hikami (Tokyo Univ.): *Calogero-Sutherland model, Macdonald polynomials, and affine Hecke algebra;*

- Hou Bo-yu (Northwest Univ., Xian): *Integrable boundary condition;*
- H. Kohno (Kyoto Univ.): *Central extension of the Yangian double and integrable models;*
- A. Kuniba (Tokyo Univ.): *Demazure modules and perfect crystals;*
- Liu Xu-Feng (Peking Univ.): *Contractions of Lie bialgebras and quantum algebras;*
- Liu Zhang-Ju (Peking Univ.): *Manin triples for Lie bialgebroids;*
- Lou Sen-yue (Ningbo Normal Coll.): *Conformal invariance and integrable models;*
- Lu Zhi-Cheng (Zhejiang Univ.): *Deformation quantisation applied to representations of Lie algebras and quantum groups;*
- Ma Zhong-Qi (Inst. of High Ener. Phys., Peking): *q–deformed boson-realization model applied to molecular vibrations;*
- Mai Zhou (Nankai Inst.): *On the infinite dimensional irreducible representations of the Yangian Y(Sl(2));*
- K. Mimachi (Kyushu Univ.): *Quantum Knizhnik-Zamolodchikov equations and Macdonald's eigenvalue;*
- M. Noumi (Kobe Univ.): *Raising operators for Macdonald polynomials and related topics;*
- S. Odake (Shinshu Univ.): *Quantum deformation of the W_N algebra;*
- J. Patera (CRM): *Algebraic properties of quasicrystals;*
- Jens-U. H. Petersen (RIMS, Kyoto):*Semi-infinite wedge construction for quantum affine algebras;*
- E. Ragoucy (Lab. d'Annecy-le-Vieux): *From N=2 gauged Wess-Zumino-Witten models to strings;*
- Y. Saint-Aubin (CRM): *On the completeness of the Bethe ansatz;*
- J. Shiraishi (Tokyo Univ.): *Deformed Virasoro algebra and solvable models;*
- M. Shiroishi (Tokyo Univ.): *Yang-Baxter equation for the one-dimensional Hubbard model;*
- P. Sodano (Univ. Perugia): *Polyakov loop operators in finite temperature gauge theories;*
- Song Xing-Chang (Peking Univ.): *The standard form of the differential calculus on a discrete group;*
- H. Ujino (Tokyo Univ.): *Orthogonal symmetric polynomials associated with the Calogero model;*
- L. Vinet (CRM): *Creation operators for the Calogero-Sutherland model and generalizations;*
- M. Walton (Univ. Lethbridge): *Fusion rings and their generators;*
- Wang Zheng-Dong (Peking Univ.): *Cocyles of loop groups;*
- Wang Zhou-Fei (Nankai Inst.): *The RTT derivation of Haldane-Shastry Hamiltonian;*
- Zeng Yunbo (Tsinghua Univ.): *Classical Poisson structures and r-matrices from constrained flows;*
- Zhao Qiang (Peking Univ.): *Unitary representations and geometric quantisation.*

46e Colloque des sciences mathématiques du Québec et 20e Conférence en mathématiques et statistique de l'Atlantique

18 - 19 October 1996, Université de Moncton, New-Brunswick

Organising Committee: Donald Violette, president; Thu Pham-Gia, director of Dép. de math. et de stat., Univ. de Moncton; Paul Deguire, in charge of the mathematics contest

Sponsors: CIPAS (Conseil des provinces Atlantiques pour les sciences), Coopération N-B/Québec, CRM, Fac. des sciences de l'Univ. de Moncton, Univ. de Moncton, ACFAS-Acadie, Conseil étudiant de la Fac. des sciences de l'Univ. de Moncton

More than 125 participants gathered at this joint meeting of mathematicians from Québec and the Maritimes. Three plenary speakers were invited: G. Brassard (Université de Montréal), L. Glass (McGill University) and D. Dupuis (Technical University of Nova Scotia). Thirty communications completed the scientific program.

The meeting was also the host of a mathematical competition for undergraduates. There were 15 teams and 29 participants. The winning teams have been:

1st prize: Stephen Finbow, Qiyan Li (St. Mary's Univ.);
2nd prize: Guario Laverty, Fai Tam (Univ. of New-Brunswick);
3rd prize: Mark Lewis, Keith Fordham (Dalhousie Univ.);
4th prize: Alex Fraser, James Worrall (Dalhousie Univ.).

Complex Analysis & Geometry

Special Session at the Winter Meeting of the Canadian Mathematical Society
7-9 December 1996, London, Ontario
Org.: Finnur Larusson, (Univ. of Western Ontario)

Starting from the notion of a holomorphic function of one complex variable, complex analysis and its alter ego analytic geometry now encompass the multiple aspects of function theory and geometry of complex analytic spaces, with or without singularities, in one and higher dimensions. It is a major branch of

modern mathematics with many important connections to other areas. There were twelve talks at the session, describing recent developments in the field.

Approximately 25 people attended the session. The speakers were: John S. Bland (Univ. of Toronto), Daniel M. Burns (Univ. of Michigan), Frederic Campana (Univ. de Nancy), Bruce Gilligan (Univ. of Regina), Christer Kiselman (Uppsala Univ.), Laszlo Lempert (Purdue Univ.), Steven Shin-Yi Lu (Univ. of Waterloo), Evgeny A. Poletsky (Syracuse Univ.), Mohan Ramachandran (SUNY at Buffalo), Thomas Ransford (Univ. Laval), Ragnar Sigurdsson (Univ. of Iceland), Berit Stensones (Univ. of Michigan).

Symposium for the 60th Birthday of Jiří Patera and Pavel Winternitz

9-11 January 1997, CRM
Org.: Y. Saint-Aubin, L. Vinet (CRM)

Jiří Patera and Pavel Winternitz were both born in 1936 and their 60th anniversaries provided a wonderful occasion to pay tribute to their remarkable scientific achievements, the enormous role that they have played in the life of the CRM, and what they have done for mathematical physics at the Université de Montréal, and in Canada for that matter.

The theme of this symposium was "Algebraic Methods and Theoretical Physics" and encompassed most of Jiří's and Pavel's work. About 60 friends gathered to celebrate the event. Among the group were collaborators, ex- and current postdoctoral fellows and students, and scientists whose career have been influenced by their work.

The titles of the main lectures give an insight into the diversity of our two colleagues' contributions: *The Fibonacci deformed harmonic oscillator* (J. Gazeau, Paris 7), *Linearizable continuous and discrete systems: the Riccati saga* (B. Grammaticos, École Polytechnique, Paris), *Isotropic geometry, Clifford modules and integrable systems* (J. Harnad, Concordia), *On the abstract structure of Lie pseudogroups of infinite type* (N. Kamran, McGill), *Lie modules with bounded multiplicities* (F. W. Lemire, Windsor), *Conditions for the existence of higher symmetries and nonlinear evolution equations on the lattice* (D. Levi, Roma), *Superintegrability on the two dimensional hyperboloid* (W. Miller Jr., Minnesota), *The relativistic oscillator and the mass spectra of baryons* (M. Moshinsky, UNAM, México), *Moving coframes* (P. J. Olver, Minnesota), *Seiberg-Witten theory without tears* (L. O'Raifeartaigh, Dublin Inst. Adv. Studies), *Contraction of Lie algebras and separation of variables* (G. Pogosyan, Dubna), *Self-dual bilinear forms for discrete Painlevé equations: the grand scheme* (A. Ramani, École Polytechnique), *Bargman representation revisited for a deformed harmonic oscillator* (G. Rideau, Paris 7), *A vector-coherent-state inducing construction for coupling coefficients* (D. J. Rowe, Toronto), *Symmetry Operations in the Brain: Music and Reasoning* (G. L. Shaw, UC at Irvine), *On the higher-dimensional Laplace transformations and applications* (K. Tenenblat, Brasilia), *Graded contractions of Lie algebras of physical interest* (J. Tolar, Czech Tech. Univ.).

Workshop on Dynamical Systems

20-25 January 1997, CRM
Org.: Dana Schlomiuk (Univ. de Montréal)

This workshop, in which six lectures were given, was held during the winter semester of the academic year 1996-1997. Two of the speakers (Robert Roussarie and Robert Kooij) spent two weeks at the CRM. Ana Guzman from UNAM-México, who was spending the academic year at the Université de Montréal, also gave a lecture in the workshop. The workshop stimulated scientific discussions, and joint projects were initiated (for example Dana Schlomiuk with Robert Roussarie on the geometry of quadratic vector fields). Robert Kooij obtained a new result during the time he spent at CRM and a CRM report based on this result and entitled "Limit cycles in quadratic systems with a weak focus and a strong focus" was written by him and André Zegeling. Students enrolled in the Master Degree and Ph.D. programs participated at the workshop and some of them benefited from the presence of foreign visitors to advance their research. The following lectures were given at this workshop:

Monday January 20

- Robert Kooij (Delft Univ. of Technology, Holland): *The distribution of limit cycles in quadratic systems I*
- Ana Guzman (UNAM-México et Univ. de Montréal): *Implicit differential equations*

Wednesday January 22

- Dana Schlomiuk (Dept. of math and stat. and CRM): *Multiplicité de courbes algébriques invariantes, géométrie et bifurcations de champs de vecteurs*
- Robert Kooij (Delft Univ. of Technology, Holland): *The distribution of limit cycles in quadratic systems II*

Thursday January 23

- Christiane Rousseau (Dept. of math. and stat. and CRM): *Méthode de Khovansky pour la cyclicité finie des graphiques*
- Robert Roussarie (Univ. de Bourgogne): *Propriété de differentiabilité pour les diagrammes de bifurcation*

Calogero-Moser-Sutherland models

10-15 March 1997, CRM

Org.: J. Avan Diejen (CRM) and L. Vinet (CRM & Univ. de Montréal)

The Calogero-Moser-Sutherland (CMS) models are certain integrable systems of n interacting particles on the line or circle, which were discovered in the early seventies by F. Calogero, J. Moser, and B. Sutherland. One of the intriguing aspects of these models is their remarkably ubiquitous nature. For instance, at the level of classical mechanics the CMS models are intimately related to the theory of solitons and nonlinear integrable wave equations (e.g. sine-Gordon, KdV, KP), the geodesic motion on simple Lie groups, questions in symplectic and algebraic geometry, …, whereas at the level of quantum mechanics there are close connections with the harmonic analysis on symmetric spaces and their quantum (i.e. q-) versions, the combinatorial theory of symmetric functions (Jack and Macdonald polynomials), the theory of special functions in several variables, random matrices, exactly solvable models in condensed matter and quantum field theory (e.g. spin models, quantum sine-Gordon theory), anyon physics, conformal field theory, … Recent years have shown an increasing amount of activity in this area of research, stimulated, for example, by the discovery of relativistic (Ruijsenaars-Schneider) and spin (Haldane-Shastry) type versions of the CMS model.

The purpose of the present workshop was to stimulate communication between experts covering a relatively wide spectrum of research in areas of mathematics and physics where the CMS systems are studied from different perspectives, and to provide an overview of the present state of the art regarding the various research activities involving CMS systems. The workshop was attended by 64 registered participants from Canada (23), USA (12) Japan (8), Russia (4), UK (3), France (2), Italy (2), Switzerland (2), Australia (1), Belgium (1), Greece (1), Germany (1), India (1), Mexico (1), The Netherlands (1), Ukraine (1).

Among the participants were two of the three founding fathers of the field: F. Calogero (Italy) and B. Sutherland (USA). In addition to the invited lectures by Professors Calogero (*Tricks of the trade: relating and deriving solvable integrable dynamical systems*) and Sutherland (*Exactly solved many-body problems: old and new results*) the program consisted of twenty-five 45-minute invited lectures by J. Avan (France), H. Awata (USA), T. Baker (Australia), R. Bhaduri (Canada), O. Bogoyavlenskij (Canada), H. Braden (UK), B. Enriquez (France), P. Di Francesco (USA), E. Gutkin (USA), F.D. Haldane (USA), V. Inozemtsev (Russia), I. Krichever (USA), F. Lesage (USA), P. Mathieu (Canada), N. Nekrasov (USA), M. Olshanetsky (Russia), A. Polychronakos (Greece), S. Ruijsenaars (The Netherlands) E. Sklyanin (Japan), T. Shiota (Japan) C. Tracy (USA), A. Varchenko (USA), A. Veselov (UK), M. Wadati (Japan), G. Wilson (UK) and fifteen 30-minute contributed lectures by Y. Berest (Canada), P. Choquard (Switzerland), F. van Diejen (Canada), M. Dijkhuizen (Japan), R. Floreanini (Italy), A. Kasman (Canada), A. N. Kirillov (Canada), K. Hasegawa (Japan), C. Quesne (Belgium) D. Sen (India), K. Taniguchi (Japan), A. Turbiner (Mexico), D. Uglov (Japan), K. Vaninsky (USA), A. Zhedanov (Ukraine).

In the week prior to the CMS workshop, Prof. Ruijsenaars gave an introductory crash course on the *Classical Calogero-Moser-Sutherland and Toda type systems* aimed mainly at graduate students of the CRM and the four Montréal based universities (Université de Montréal, McGill University, Concordia University and UQAM).

Aside from the workshop program, Prof. Calogero — who is also secretary general of the Pugwash conferences on science and world affairs — presented a special lecture entitled: *A nuclear-weapon-free world: is it desirable? is it feasible? is it likely?* In this connection an interview with Prof. Calogero appeared in the March 24, 1997 issue of *Forum*, the weekly newspaper of the Université de Montréal (vol. 31, no. 25).

Themes addressed by the lecturers include: dynamical R matrices for CMS models; the underlying algebraic structure of CMS models and their relativistic- and spin-type generalizations; Dunkl operators and multivariable Hermite polynomials; the problem of lacunae and analysis on root systems; collective field methods and two-dimensional systems; symmetries of integrable Hamiltonian systems and applications; functional equations and R-matrix constructions associated with CM models; tricks for relating and deriving solvable and integrable dynamical systems; Coulomb system with energy spectrum equivalent to CMS model; meander determinants; quantisation of Poisson brackets on symmetric spaces and multivariable Askey-Wilson polynomials; elliptic quantum groups and quasi-Hopf algebras; conditions for integrability of an n-particle model; the Haldane-Shastry spin chain and the ideal spinon gas model; Ruijsenaars commuting difference operators from Belavin's elliptic R-matrix; integrability and diagonalization of the

Haldane-Shastry spin chain with elliptic interaction; bispectrality and linearisation of Calogero-Moser systems; elliptic solutions to difference nonlinear equations and Bethe ansatz; Yangian symmetry in conformal field theory; CMS systems in gauge theories; the Painlevé-Calogero correspondence; multidimensional Calogero models; three-body generalizations of the Sutherland problem; generalized Lamé functions; multispecies CMS models; Calogero-Moser and KP hierarchy; separation of variables in Jack and Macdonald polynomials; exactly solved many body problems, non-diffractive scattering and asymptotic Bethe ansatz; differential operators that commute with the inverse-square Hamiltonian; distribution of largest eigenvalue in Gaussian random matrix ensembles; quasi-exactly solvable many-body problems; Yangian Gelfand-Zetlin bases, *gl(n)*-Jack polynomials and dynamical correlation functions for the CMS model; a hierarchy of CMS systems with polynomial wave functions; thermodynamics of Calogero-Moser potentials and the Seiberg-Witten solution; algebraic Bethe ansatz for the elliptic quantum group $E_{t,h}(sl_2)$; algebraic integrability of generalized Calogero-Moser systems and deformations of root systems; towards an algebraic treatment of Calogero models; the quantum Calogero model: integrability, algebraic structures and orthogonal basis; collisions in Calogero-Moser models in the complex domain; multidimensional factorization method and multivariable Krawtchouk polynomials; quadratic algebras, Dunkl elements and Schubert calculus.

The Bispectral Problem

17-21 March 1997
Org.: J. Harnad, A. Kasman and P. Winternitz

It has been 15 years since F. Alberto Grünbaum introduced the notion of bispectrality of an operator. Originally proposed in the context of medical imaging, the "Bispectral Problem" has since been related to diverse areas of mathematical physics including: representation theory, Darboux transformations, integrable systems of particles, soliton equations, orthogonal polynomials, isomonodromy, and Huygens' principle. Interest in bispectrality continues to grow as new connections are found.

This workshop was the first scientific meeting devoted to the bispectral problem. Many of the 38 registered participants of the workshop were researchers who have made significant contributions to our understanding of bispectrality, and others were mathematicians and physicists who work in related fields. Thus, the workshop fulfilled its goal of bringing together experts from a wide variety of areas to collectively address the bispectral problem.

The scheduled talks included both surveys of some of the research that form the foundation of the investigation of the field and exciting new results. Two topics of particular interest were recent results by Horozov et al. relating bispectrality to the highest weight representations of $W_{1+\infty}$ algebras and new developments in discrete versions of the bispectral problem. All those present benefited from the superb talks given by the invited and contributing speakers and also from the informal discussion groups that they inspired.

The principal speakers at this meeting were: Y. Berest (Université de Montréal), F. A. Grünbaum (University of California, Berkeley), A. Kasman (Concordia University and CRM), L. Haine (Université Catholique de Louvain), J. Harnad (Concordia University and CRM), E. Horozov (Sofia University), A. Its (Indiana University-Purdue University at Indianapolis), F. Magri (Università di Milano), V. Matveev (Université de Bourgogne), A. Orlov (Université de Montréal), A. Radul (Howard University), M. Rothstein (University of Georgia — Athens), T. Shiota (Kyoto University), A. Veselov (Loughborough University), G. Wilson (Imperial College), and Jorge P. Zubelli (IMPA, Brazil). In addition, there were excellent contributed talks by M. Gekhtman (University of Michigan), M. Kovalyov (University of Alberta), F. Levstein (Universidad Nacional de Cordoba), J. McKay (Concordia University) V. Retakh (Harvard University), and J. van de Leur (University of Twente).

The proceedings of this workshop will be published in the CRM-AMS Proceedings Series and should prove to be a valuable resource for those working with bispectrality and related topics.

International Workshop on Parallel Algorithms and Software for CFD

24 - 25 March 1997, at CERCA
Sponsors: CERCA (Centre de Recherche en Calcul Appliqué), CRM, Département d'informatique et de recherche opérationnelle (Univ. de Montréal), Silicon Graphics Inc., Environment Canada
Org.: Andrei Malevsky (CERCA), Maurice Meneguzzi (Saclay), Ahmed Sameh (Univ. of Minnesota)

Computational Fluid Dynamics (CFD) problems such as numerical weather forecasting, modelling of flows around aircraft and vehicles, and oil reservoir

simulations are among the major clients of High Performance Computing (HPC) technology. The arrival of distributed-memory massively parallel processors (MPP) had promised a dramatic increase in processing speed and computer memory available for applications, and several researchers have demonstrated that their CFD applications can be ported to MPP's with a significant speed-up. Despite these facts, parallel computing has not yet gained a widespread acceptance in the scientific and engineering communities, in part because of lack of software to support the CFD applications. Until recently, every parallel computer manufacturer had offered his own version of software, often incompatible with the products of other vendors. A few general-purpose problem-solving techniques have been available, but achieving good performance on parallel machines resembled an art more than a science.

About 40 specialists in CFD and parallel computing were invited at CERCA to discuss this issue, within the framework of an international workshop. The main conclusions were as follows:

- Y. Saad (University of Minnesota) presented iterative algorithms to solve distributed linear systems. The main problem here is to find an efficient preconditioner which can be adapted to a distributed data structure. The choice of preconditioners depends on the computer architecture and, most of all, on the granularity of parallelism. A general purpose library of iterative solvers must include accelerators, parallel preconditioners, inter-processor communication tools, and graph partitioning algorithms.
- Several research groups are developing parallel linear algebra libraries intended to support distributed message-passing codes. Among these libraries are Aztec (Sandia National Laboratory), PETSc (Argonne National Laboratory), ScaLapack (Oak Ridge National Laboratory), and P_SPARSLIB (University of Minnesota). These libraries are based on the Message Passing Interface (MPI) standard which now offers a complete environment for distributed-memory applications. The future developments of the MPI were outlined by W. Gropp (Argonne National Laboratory). The MPI-2 proposes a form of parallel I/O that will be integrated with the MPI programming model. However, these developments have yet to find their way to the mainstream user community.
- Many researchers still consider investment of their time in adapting their codes to a distributed-memory paradigm as a risky business. Debugging of parallel codes and viewing distributed data remain a challenge.
- The pV3 parallel visualization tool kit presented by K. Jordan (IBM) permits to browse through distributed data and even interact with the processes of simulation.

Researchers apply the HPC technology to model diverse CFD problems. A variety of numerical methods have been used on distributed-memory architectures:

- The parallel implementation of the vortex method presented by A. Gharakhani (MIT) allowed to model a mixing layer and jet flows, vortex breakdown phenomena, buoyant and fire plumes, flows over vehicles and flows inside internal combustion engines.
- M. Meneguzzi (Centre d'Études de Saclay) and T. Tezduyar (University of Minnesota) have simulated fluid-particle interactions. The complex finite-element simulations of Tezduyar were carried out on distributed-memory machines (CRAY-T3D and CM5) with several hundred processors. These simulations prove that the massively parallel distributed-memory machines can be successfully employed for large-scale CFD simulations in a real production mode.
- H. Herrmann (University of Stuttgart) simulated flows in granular materials on parallel computers using the molecular dynamics technique. Granular materials may behave like fluids, but sometimes exhibit many intriguing phenomena such as heap formation under vibration, size segregation, and the emission of density waves. The numerical simulations helped to understand these effects which otherwise could not be modelled or fully explained.
- M. Latendresse (Université de Montréal) presented an approach to task creation in the framework of a shared-memory programming model. This algorithm is called Lazy Task Creation and allows the user to specify where operations can be executed in parallel without a major code modification.
- P. Tackley (UCLA) has demonstrated how parallel computing can be applied to solve fundamental problems of geodynamics. His numerical models described complex 3D behaviour of the Earth's mantle. He has simulated mantle convection taking into account phase transition and varying material properties.
- An engineering application of parallel CFD has been presented by J. F. Hétu (IMI/NRC). He has used a distributed-memory parallel finite-element

solver to simulate mould-filling problems. His work has demonstrated that 3D finite-element codes can be efficiently implemented on distributed-memory machines and applied to various industrial CFD problems.

Numerical weather prediction is among the major users of HPC technology and is often referred to as one of the Grand Challenge problems of computing. S. Thomas (Environment Canada) presented the parallel distributed-memory implementation of the Mesoscale Compressible Community Model (MC2). The parallel model allows to increase the resolution of regional weather simulations and can also be used for high-resolution studies of atmospheric turbulence.

All these applications have proved the feasibility of the use of distributed-memory parallel architectures for CFD research and engineering.

Hopf Algebras and Group Rings

5-10 May 1997, Memorial University of Newfoundland (MUN), St. John's, Newfoundland
Org.: M. Beattie (Mount Allison Univ.), E. Jespers (MUN)
Sponsors: Atlantic Association for Research in the Mathematical Sciences (AARMS), CRM, Fields Institute, Dalhousie Univ., Mount Allison Univ., MUN, Univ. of New Brunswick (UNB)

The aim of this workshop was to foster cooperation and collaboration between algebra groups in the Atlantic provinces, including graduate students. The workshop was timed in early May to take advantage of planned visits by several international visitors at that time.

Dr. Yuly Billig (UNB, Fredericton) offered a short course (10 hours) on Kac-Moody algebras in the afternoons; this opportunity alone justified the workshop. In addition to the mini-course on Kac-Moody algebras, eighteen of the twenty-four participants presented their recent work. Of these talks, half were primarily about problems in group rings; the others were concerned with problems in more general Hopf algebras. In the course of the week, several working groups emerged.

Of the twenty-four participants, fourteen came from Canada's Atlantic region, two from other regions of Canada, three from the U. S., four from Europe and one from South America.

The workshop was planned to be as informal as possible, to encourage participants to talk about their latest work, ideas and conjectures, to share problems and expertise. Judging from comments at the close of the week, participants found the workshop valuable and tentative plans for another "Atlantic Algebra Workshop" are underway.

Joint Meeting: Canadian Operator Algebra Symposium & Great Plains Operator Theory Seminar

18 - 22 May 1997, Queen's University, Kingston, Ont.
Org.: James A. Mingo (Queen's Univ.), Norberto Salinas (Univ. of Kansas)

This joint meeting of the two symposia celebrated the 25th meeting of the Canadian symposium, the 60th birthday of Peter Fillmore, and the 50th birthday of Alain Connes.

The Canadian symposium first met on March 31, 1972 at the University of Toronto. It has met every year since then (except 1979) to present the work of Canadian and foreign researchers in operator algebras and operator theory. An important feature of the symposium has been the support (both financial and moral) given to graduate students and junior researchers. The success of the symposium may be gauged by its longevity and the number of similar conferences it has spawned: the Great Plains Operator Theory Seminar, the West Coast Operator Algebra Conference, and the annual meetings of a group funded by the European Union.

161 participants from Argentina, Australia, Canada, Denmark, France, Germany, Greece, Ireland, Japan, Mexico, Norway, Poland, Slovenia, Switzerland, Turkey, Venezuela, Uruguay, and the United States came to Kingston to hear talks from seven invited speakers: D. Bisch (Santa Barbara), M. Dadarlat (Purdue), T. Giordano (Ottawa), N. Higson (Penn. State), E. Kirchberg (Humbolt), A. Nica (Michigan), G. Pisier (Paris 6 and Texas A & M). An eighth invited speaker (A. Connes, Collège de France) was unable to attend for health reasons. Besides the invited talks, there were 89 contributed papers.

The main themes of the conference were: classification of C*-algebras, K-theory and E-theory, subfactors, noncommutative probability, non-self-adjoint algebras, completely bounded mappings and operator spaces, C*-algebras and dynamical systems, and operator theory.

Montréal '97 Summer School
Nonlinear Dynamics in Physiology and Medicine: An Intensive Introduction

25 May - 6 June 1997, McGill University
Org.: Leon Glass, Michael Mackey, Daniel Kaplan (McGill)

This second Summer School on Nonlinear Dynamics in Physiology and Medicine, Montréal 97, was organized and run based on the highly successful Montréal 96 of last yearThis year's summer school had lectures held in the Department of Physiology, and computer laboratories held in the Faculty of Arts Computer Laboratory. Montréal 97 was partially supported by the Department of Energy (USA) and Math Works Inc. who supplied Matlab software. The Centre de Recherches Mathématiques partially defrayed student tuition fees, and the McGill University Department of Physiology provided infrastructure and administrative support.

The more than 80 students were selected on a first-come, first-served basis from over 100 applicants. They came from 18 countries, ranging in subject specialization from biology and medicine through theoretical physics and applied mathematics. Student housing was provided in the McGill University dormitories.

Three features of Montréal 97 were unique. The first was that the lectures were given by individuals with first-hand knowledge in the practical application of nonlinear dynamics to biological problems. Often in such schools, lecturers have one skill or the other, but rarely both. The second was the inclusion and integration of lectures on time series analysis techniques with concepts from dynamics. The third was the daily computer laboratory designed to illustrate the concepts of the lectures through numerical experiments using software written by the lecturers. Graduate and undergraduate students of the CNLD served as laboratory assistants, as did the lecturers, to supplement the instructions given in the laboratory manual.

Based on the evaluations by the students attending, the response was even more positive that the one held last year. By all accounts, the students found it to be a highly rewarding experience, and we are all justifiably proud of the way in which we have organized and carried off this rather unique event.

Those interested in finding out more details of Montréal 97 may consult:

`http://www.cnd.mcgill.ca/`

A sequel, Montréal 99, is under consideration.

18th Annual Meeting of the Canadian Applied Mathematics Society

30 May - 1 June 1997, Fields Institute
Co-chairs of org. comm.: A. Lawniczak (Guelph), W. Langford (Fields), P Sullivan (Waterloo)

The three-day meeting included 10 plenary lectures and 18 mini-symposia on bioinformatics, communication networks, computing technology in mathematics education, cryptography, environmental problems, financial mathematics and risk management, fractal image compression, geophysical fluid dynamics, industrial mathematics, mathematics in the biomedical sciences, mesoscale phenomena in fluids and materials, modelling of polymers, neural networks, numerical analysis of differential equations, parallel computation, topics in pulsatile flow, research partnerships of academia, industry and government, and nonlinear waves.

CRM Prizes

CRM/Fields Prize

The Centre de recherches mathématiques and the Fields Institute announced in early 1994 the creation of a new prize aiming at recognizing exceptional work in the mathematical sciences. The recipient is chosen by the Advisory Committee of the CRM and the Scientific Advisory Panel of the Fields Institute on the basis of outstanding contributions to the advancement of research. The main selection criterion is research excellence. A prize of $ 5000 is awarded and the recipient presents a lecture at the CRM and the Fields Institute. The previous winners of the CRM/Fields Prize were Prof. H. S. M. Coxeter (University of Toronto) and Prof. G. A. Elliott (University of Toronto).

The 1996 CRM-Fields Institute Prize was awarded to Professor James Arthur of the Department of Mathematics, University of Toronto. Professor Arthur was honoured for a career of research contributions in a variety of mathematical fields including harmonic analysis, number theory, Lie-group theory, representation theory, and geometry. He has combined tools in each of these fields to achieve a deep understanding of basic mathematical phenomena. To quote the letter of nomination: "Arthur is a powerful mathematician whose trace formula is having a profound effect on representation theory and automorphic forms", and "His recent work and conjectures on Arthur's packets and the local trace formula are major milestones that are setting the direction for research in a central part of mathematics."

James Arthur obtained the B.Sc. (1966) and the M.Sc. (1967) in Mathematics from the University of Toronto and his Ph.D. in 1970 from Yale University under the direction of Robert Langlands. He then spent time at Princeton, Duke and Yale Universities before coming to the Department of Mathematics of the University of Toronto in 1978. He currently holds the position of University Professor.

Professor Arthur has written over forty articles and given numerous invited lectures at important meetings. Among the honours he has received are the Sloan Fellowship and the E.W.R. Steacie Memorial Fellowship. He has also been named a Fellow of the Royal Society of London and a Fellow of the Royal Society of Canada which presented him the Synge Award in 1987.

Professor Arthur visited the CRM on April 4, 1997 to deliver the 1996 CRM-Fields Institute Prize Lecture which was entitled *Harmonic Analysis and Trace Formulas.* An abstract of this talk follows:

Harmonic analysis could be interpreted broadly as a general principle which relates analytic and geometric objects. Examples occur throughout many areas of mathematics. In group theory, the geometric objects are conjugacy classes, the analytic objects are irreducible characters, and the two can be related by means of trace formulas. We shall give a general introduction to trace formulas, and their applications to group representations and number theory.

André-Aisenstadt Prize

Created in 1991, the André-Aisenstadt Mathematics Prize is intended to recognize and reward talented young Canadian mathematicians. The Prize, which is given for research achievement in pure and applied mathematics, consists of a $ 3000 award. The recipient is chosen by the CRM Advisory Committee. At the time of nomination, candidates must be Canadian citizens or permanent residents of Canada, and no more than seven years from their Ph.D. The previous winners of the André-Aisenstadt Prize were Niky Kamran (1991), Ian Putnam (1992), Michael Ward (1994), Nigel Higson (1994) and Adrian S. Lewis (1995).

The CRM Advisory Committee recommended the awarding of two Aisenstadt Prizes for the academic year 1996-97. These went to Henri Darmon and Lisa Jeffrey both of McGill University.

Henri Darmon was cited for his remarkable work in the area of elliptic curves, particularly for his refinements of the famous Birch Swinnerton-Dyer conjecture. He has also made significant contributions to research on variants of the Fermat equation. In addition to his superb research contributions, Professor Darmon is a splendid expositor and a recent paper explaining the subtleties of Wiles' work on the Shimura-Taniyama conjecture has been widely celebrated.

Professor Darmon obtained his B.Sc. in Mathematics and Computer Science at McGill University in 1987 and his Ph.D. in Mathematics at Harvard University in 1991. He then spent 4 years at Princeton University before coming to McGill University where he is currently an associate professor.

He has also held various visiting positions at such institutions as ETH in Zurich, the Mathematical Sciences Research Institute in Berkeley, and IHES in Paris.

Henri Darmon has published more than 26 research papers and won numerous awards, among them an Alfred P. Sloan Doctoral Dissertation Fellowship and an Alfred P. Sloan Research Award.

Lisa Jeffrey was awarded the Aisenstadt Prize for her distinguished research contributions in Symplectic Geometry and various aspects of the relation between Topology and Physics. In particular, in joint work with Frances Kirwan, she obtained a complete description of the cohomology ring of the moduli space of vector bundles on a Riemann surface, solving an important conjecture of Witten. Techniques invented in the course of this work have proved useful in solving other significant problems as well.

Professor Jeffrey obtained the A .B. at Princeton University, the M.A. at Cambridge University and the Ph.D. at Oxford University in 1992 under the direction of M. F. Atiyah. She then held positions at the Institute for Advanced Study, Cambridge University, and Princeton University before coming to McGill University in 1995 where she is currently Associate Professor of Mathematics.

Professor Jeffrey has written over 21 research papers and numerous review articles. Among the honours she has received are the Kusaka Memorial Prize in Physics from Princeton University and the Smith Prize from Cambridge University.

The two Aisenstadt prizewinners gave lectures on their work at the CRM on February 28, 1997. Professor Darmon's lecture was entitled "Faltings plus epsilon et l'équation de Fermat généralisée" and Professor Jeffrey's was entitled "Flat connections on Riemann surfaces."

CRM-CAP Prize

The CRM-CAP Prize is given for outstanding contributions to theoretical and mathematical physics. The first winner (1995) was Werner Israel (University of Alberta).

1996 CRM-CAP Prize:
Professor William J. Unruh
Physics Dept., University of British Columbia

Bill Unruh was born and raised in Winnipeg. He graduated in 1967 with a B.Sc. from the University of Manitoba and received his M.A. and Ph.D. from Princeton University. An NRC Postdoctoral fellowship taken at Birkbeck College, London was followed by a Miller Fellowship at Berkeley. Bill then returned to Canada to teach in the Department of Applied Mathematics at McMaster University. He was recruited by the UBC Physics Department in 1976. Since 1986, he has also been the Director of the Cosmology Program of the Canadian Institute for Advanced Research. Due in large part to his inspirational leadership, this is a very successful program with a high international profile.

Bill is an exceptionally gifted scientist of truly international stature. His contributions to theoretical physics reflect range, versatility and creativity. His work can be categorised under five broad headings: quantum field theory in curved space-times; fundamental basis of quantum mechanics and measurement theory; cosmology; foundations of quantum gravity; and, more recently quantum computers.

He was first internationally recognised for his pioneering work on the quantum radiation from black holes. His 1976 paper on acceleration radiation is universally acknowledged as a landmark in the field. This classic contribution, together with Hawking's simultaneous and complementary discovery that black holes are hot, revealed deep and previously unsuspected interconnections, linking quantum theory, gravity acceleration and thermodynamics. The "Unruh vacuum", the "Unruh temperature" and "Unruh detectors" are phrases used by workers in this field and reflect the importance of his contributions. Currently he has been examining the mechanism of black hole evaporation and particle creation near the horizon by using a hydrodynamic model.

Bill's study of quantum non-demolition measurements have been relevant to the problem of gravitational wave detection, and his explanation (with Zurek) of why "Schrödinger cat states" are not generally observed in macroscopic systems is widely accepted.

He has also been a major influence in the arena of cosmology. In 1985 (with Mazenko and Wald) the "new inflation" theory was shown to be flawed. A paper (with Wald) studied the damping mechanisms for coherent oscillations of axions and put constraints

on the observation of these dark-matter candidates. Bill has also made important studies of cosmic strings and made a significant contribution to the debate as to why the cosmological constant is so small.

From the early 1980's to the present, he has thought about quantum gravity and emphasised the crucial role of time. There is a fundamental incompatibility between the current theories of quantum mechanics and general relativity which has to be reconciled in any new theory that seeks to explain the physical world at all levels.

Although he is an expert in theoretical and mathematical physics, Bill is interested in science in general and gets involved with the problems of his experimental colleagues. His fields of interest range from applied subjects such as intercalation batteries to interesting contributions to the American Journal of Physics. Importantly he is also willing to participate in outreach programs from school students. He has served on the Canada Council Killam Selection Committee (1984-88) and was a member of the NSERC Space and Astronomy Committee (1989-92).

His contributions to science have been recognised by many awards and prizes. As an undergraduate he placed in the top 10 of the William Putnam Mathematics Competition (1966) and won First Place in the C.A.P. Undergraduate Examination (1967). He was made a Fellow of the Royal Society of Canada in 1984. Other awards include an Alfred P. Sloan Fellowship (1978-80), the Rutherford Medal from the Royal Society of Canada (1982), the C.A.P. Herzberg Medal (1983), the Steacie Prize (1984), the Steacie Fellowship (1984-86), the B.C. Science Council Distinguished Research (1990). In 1995 he was awarded the C.A.P. Medal of Achievement, and this year he was the recipient of the Canada Council lzaak Walton Killam Memorial Prize in the Natural Sciences.

Bill's many friends and acquaintances in Canada and abroad will share the pleasure of his UBC colleagues in this award. Although he has won other prestigious prizes, this one is special because it represents the appreciation of his talents by his peers in Theoretical and Mathematical Physics.

The above text by Brian G. Turrell (UBC) is taken from Physics in Canada, *July/August 1996.*

1997 CRM-CAP Prize:
Professor Ian Affleck
Physics Dept., University of British Columbia

The CAP-CRM prize in theoretical physics is presented to Dr. Ian Affleck of the University of British Columbia for his very successful work in theoretical condensed matter physics highlighting field-theoretic methods and related mathematical physics.

In the 1970's and the early 1980's, most applications of field theory to critical phenomena were devoted to classical systems, mainly through renormalisation-group methods. Dr. Affleck has been one of the first physicists to systematically apply quantum field theory methods to the more subtle problem of quantum critical phenomena, focusing mainly on one-dimensional systems. On this subject he made important contributions in the period 1985-89. For instance, he proposed that Wess-Zumino-Witten models are the fixed points governing quantum spin chains. He also related this description of spin chains with the large-spin approximation based on the nonlinear sigma model. [Wess-Zumino-Witten models are two-dimensional quantum field theories with Lie group symmetry; they can be regarded as the building blocks of all two-dimensional quantum field theories having conformal invariance.] He also made significant contributions to the physics of quasi-one-dimensional spin-1 antiferromagnets in relation with the Haldane gap. Some of his discoveries in the area of quantum spin chains are now standard material in theoretical physics. The essentials of his results and insights were reported in the remarkable lectures presented at Les Houches in 1988, which became an influential review paper.

In 1990, in collaboration with A. Ludwig, he initiated a very important research program on the applications of the recently discovered boundary conformal field theory (formulated by Cardy) to various one-dimensional quantum impurity problems. These applications are mainly in condensed matter physics (e.g., the Kondo effect and its multi-channel and higher-spin generalizations, quantum wires, etc.) but some are related to particle physics and cosmology (the Callan-Rubakov effect describing baryon scattering off monopoles). Conformal field theory provides numerous examples of exactly solvable models (i.e, of which all correlation functions can be calculated exactly). However, apart from two-point functions from which critical exponents may be extracted, very little can be compared with experiments. In their approach to

quantum impurities problems, Affleck and Ludwig have shown that various physical quantities (resistivity, specific heat, etc.) can indeed be calculated and compared with experimental data. These studies, in turn, have stimulated new experimental work, which further demonstrates the impact of Dr. Affleck's work. Moreover, this work often provides striking and original physical realizations of some of the most abstract constructions of conformal field theory, such as fusion rules or conformal embeddings in the treatment of the multi-channel Kondo effect.

Although Dr. Affleck's main focus has been the application of field theory methods to condensed matter physics, he has to his credit two fundamental discoveries in conformal field theory. One is the interpretation of the conformal anomaly — the basic parameter of a conformal theory — as a finite-size or Casimir effect. (The same result was found independently by Blöte, Cardy and Nightingale.) The second one, obtained in collaboration with Ludwig, is the discovery of the g-function, the "ground-state degeneracy", a measure of the impurity entropy, which has been shown to be always decreasing under renormalisation (in close analogy with the Zamolodchikov *c*-theorem). The importance of both contributions has been widely acknowledged.

Dr. Affleck joined UBC in 1987 as professor and fellow of the CIAR Cosmology Program. He is now also an associate of the CIAR Superconductivity Program. He graduated from Trent University in 1975 and obtained his Ph.D from Harvard University in 1979. He was junior fellow of the Harvard Society of Fellows from 1979 to 1981 and then associate professor at Princeton University until 1987. He received various distinctions since his arrival at UBC: Steacie Prize in 1988, the CAP Herzberg Medal in 1989, elected Fellow of the Royal Society of Canada in 1991, Rutherford Medal of the Royal Society of Canada in 1991, UBC Senior Killam Research Prize and UBC Jacob Bieley Prize in 1992.

The above text by Pierre Mathieu (Université Laval) is taken from Physics in Canada, *July/August 1997.*

Members' Seminars and Special Events

The members of the CRM are encouraged to organise seminars and other scientific activities during their stay at the CRM, and the CRM hosted several seminar series during the year 1996-97:

- **"History of Combinatorics and Group Theory"**
  Org.: Liliane Beaulieu (CRM)

- **"Nonlinear Analysis"**
  Org.: Marlène Frigon (Univ. de Montréal)

- **"Integrable Systems"**
  Org.: John Harnad (CRM and Concordia Univ.) et Alex Kasman (CRM and Concordia Univ.)

- **"Mathematical Physics "**
  Org.: Pavel Winternitz (CRM and Univ. de Montréal)

- **"Theory of Algebraic Curves"**
  Org.: Sadok Kallel (CRM)

There were also a few special events:

- **12 March 1997**
  Francesco Calogero, Pugwash Conferences on Science and World Affairs
  Professor Calogero, while attending the CRM's conference on the Calogero-Moser-Sutherland models, gave a general-audience talk on *"A nuclear-weapon-free world: is it desirable? is it feasible? is it likely?"* Professor Calogero is secretary-general of the Pugwash Conferences and represented the movement at the ceremony awarding it a Nobel Peace Prize.
  Org.: Luc Vinet (CRM)

- **26 May 1997**
  Jean-Christophe Yoccoz, Univ. de Paris-Sud
  The Beatty Memorial Fund at McGill University sponsors public conferences on a wide variety of topics. The CRM, jointly with the Beatty Fund and the French Consulate, sponsored a visit by Professor Jean-Christophe Yoccoz, Fields Medallist and professor at the Collège de France. Prof. Yoccoz gave a public lecture at McGill on *"Celestial Mechanics, Statistical Mechanics and Dynamical Systems"* which was attended by over 300 people, and a more technical lecture at the CRM, with title *"Weakly hyperbolic dynamics."*
  Org.: Jacques Hurtubise (McGill Univ.)

- **29-30 May 1997**
  Carlo Matessi, IGBE-CNR, Pavia
  "Reproductive conflicts in social hymenoptera" and *"Genetic Canalisation and Pre-adaptation"*
  Special Lectures on Population Genetics
  Org.: Sabin Lessard (Univ. de Montréal)

CRM-ISM Colloquium

The CRM, together with the Institut des Sciences Mathématiques, the graduate consortium of the four Montréal Universities, runs the Montréal mathematics colloquium, which, during the university year, organises survey talks by distinguished mathematicians on topics of current interests.

- **20 September 1996**
  Henri Darmon, McGill Univ.
  "Les courbes elliptiques, de Fermat à Wiles"

- **4 October 1996**
  Richard Melrose, MIT
  "Traces, signatures and index theorems"

- **11 October 1996**
  Jean-Pierre Serre, Collège de France
  "Sous-groupes finis des groupes de Lie"

- **18 October 1996**
  Steve M. Gersten, Univ. of Utah
  "Hyperbolic Groups"

- **8 November 1996**
  David Handelman, Univ. d'Ottawa
  "Small matrices, small problems; BIG MATRICES, big problems"

- **15 November 1996**
  Pierre L'Ecuyer, Univ. de Montréal
  "Générateurs pseudo-aléatoires"

- **29 November 1996**
  James Sethian, Univ. of California, Berkeley
  "Level Set Methods and Fast Marching Methods: Tracking Moving Interfaces in Semiconductor Manufacturing, Computer Vision, and Robotic Navigation"

- **6 December 1996**
  Ian Putnam, Univ. of Victoria
  "C-algebras as noncommutative spaces and applications to dynamical systems"*

- **13 December 1996**
  A. M. Garsia, Univ. of California, San Diego
  "Open problems in the theory of harmonic polynomials"

- **24 January 1997**
  Yannis G. Kevrekidis, Princeton Univ.
  "Catalytic Pattern Formation on Microdesigned Surfaces"

- **7 February 1997**
  François Bergeron, Univ. du Québec à Montréal
  "Algèbres de descentes de groupes de Coxeter"

- **14 February 1997**
  Daniel W. Stroock, M.I.T.
  "Some thoughts about Riemannian structures on spaces of paths in Riemannian manifolds"

- **21 February 1997**
  Francis Bonahon, Univ. of Southern California, Los Angeles
  "Simple closed curves on surfaces"

- **7 March 1997**
  Maciej Zworski, Univ. of Toronto
  "Resonances for Black Holes"

- **21 March 1997**
  Serge Lang, Yale Univ.
  "The ubiquitous heat kernel"

- **27 March 1997**
  Richard Taylor, Harvard Univ.
  "Galois groups and modular forms"

- **11 April 1997**
  Alexandru Buium, Univ. of New Mexico
  "Derivatives of integer numbers"

- **17 April 1997**
  George Oster, Univ. of California, Berkeley
  "Modelling Molecular Motors I: The Flagellar Motors and ATP synthase"

- **25 April 1997**
  David Benney, MIT
  "Long Wave Problems in Fluid Mechanics"

- **2 May 1997**
  Andrew Odlyzko, AT&T Bell Laboratories
  "Increasing subsequences in random permutations"

COMING EVENTS

Theme Year 1997-1998: Statistics

Org.: Jerry F. Lawless (Waterloo), Marc Moore (École polytechnique), Nancy Reid (Chair, Toronto), Yannis Yatracos (Montréal)

Overview

The Canadian school of statistics is extremely active and a theme year in statistics is most timely. Theoretical work is done in essentially all Canadian universities. Moreover there are many professionals using and developing statistics in governmental service (Statistics Canada and its provincial counterparts, etc.), in other disciplines (like the human, environmental and health sciences), and in private companies (e.g. independent poll services).

The theme year in statistics will emphasize several current directions in the theory and application of statistics, with particular emphasis on problems involving dependent data. Five areas of concentration have been selected: the interface between computation and theoretical statistics, spatial statistics, nonparametric functional estimation, statistical methods in epidemiology and genetic epidemiology, and longitudinal data analysis. The organizers for these programs have emphasized, as much as is feasible, interaction with researchers having special expertise in applications.

Since the participants will form a blend of university professors, postdoctoral fellows, students, and users and practitioners of statistics, the theme-year organizers have favoured short, focused workshops to allow a larger participation of professionals. The year offers 12 workshops, 2 symposia, 3 lectures series of which two will be given under the auspices of the CRM's prestigious Chaire Aisenstadt, and the CRM Summer School at Banff. Professor Peter Hall (The Australian National University) will give the first part of the André-Aisenstadt Lectures at the CRM in conjunction with the workshop on Nonparametric Functional Estimation in October 1997. Sir David Cox will hold the second part of the Chaire, and will deliver a series of lectures in May 1998. The events are presented below in the order they are to take place. They will be held at the CRM unless otherwise indicated.

CRM Summer School at Banff: *Likelihood and Asymptotics*

1-10 August 1997, Banff
Org.: Thomas J. DiCiccio (Cornell)

The 7th CRM Summer School will be on Likelihood and Asymptotics. Likelihood and related concepts, which are of central importance in statistical theory and methodology, have recently undergone intensive development. Some of the topics receiving special attention include: ancillarity and conditionality; prediction; the construction of likelihood-like objects, such as modified profile likelihoods and nonparametric likelihoods; and the connections between frequentist and Bayesian inference. Old and new asymptotic methods have been essential to these investigations. The purpose of the summer school is to bring junior and senior researchers and graduate students together to explore the recent developments and new directions in the area of likelihood, interpreted in a very broad sense.

The list of the invited lecturers includes:
O. E. Barndorff-Nielsen, J. G. Booth, R. W. Butler, A. C. Davison, B. de Finetti, C. A. Field, D. V. Hinkley, D. A. S. Fraser, J. L. Jensen, J. E. Kolassa, B. G. Lindsay, P. McCullagh, A. C. Monti, P. Mykland, D. A. Pierce, N. Reid, E. M. Ronchetti, T. A. Severini, I. M. Skovgaard, S. E. Stern, T. J. Sweeting, M. E. Thompson, S. Wang, G. A. Young.

Workshop on Resampling Methods

14-20 September 1997
Org.: Christian Léger (Montréal), Joseph Romano (Stanford), Rob Tibshirani (Toronto)

Since the advent of fast computing, resampling methods have played a major role in developing new tools for statisticians. In recent years, resampling methods have been developed for more complicated problems, including time and spatially dependent data, nonparametric regression methods, and model selection. This workshop will present the latest theoretical and practical advances in the field.

The list of the invited speakers includes:
P. J. Bickel, A. C. Davison, T. J. DiCiccio*, T. C. Hesterberg*, S. N. Lahiri, R. Y. Liu, S. Paparoditis*, D. N. Politis, J. Shao, M. Sherman*, R. R. Sitter, L. A. Thombs. (* indicates a speaker to be confirmed.)

Workshop on Symbolic Computation

21-27 September 1997
Org.: James Stafford (Western Ontario)

In recent years we have witnessed an increase in the use of computer algebra environments in statistical research, teaching, and consulting. The goals of the workshop are to emphasize:
(i) the structure of symbolic environments,
(ii) computer algebra research in statistics,
(iii) statistical research that involves computer algebra.

There will be a major emphasis on the third of these, as a thorough understanding of this is needed to address the second and to design symbolic environments for statistics.

The list of the invited speakers includes:
D. Andrews, D. Bellhouse, J. Borwein, D. Bradhurst, R. Corless, A. C. Davison, K. de Rossi, T. DiCiccio, C. Field, R. Gatto, D. Hinkley, A. Karian, W. S. Kendall, J. Kolassa, M. Lesperance, N. Lazar, P. Mykland, P. McCullagh, W. Olford, D. Pierce, J. Rao, G. Roberts, E. Ronchetti, A. Salvan, B. Smith, R. Thomas, Krishnaswami, R. Waterman, H. Wynn.

Symposium on Nonparametric Functional Estimation

13-24 October 1997
Org.: Luc Devroye (McGill), George Roussas (UC Davis), Yannis Yatracos (Montréal)

Nonparametric functional estimation is widely used in theory and applications, with emphasis on the estimation of density functions, distribution functions, quantile functions, regression functions, and nonlinear functionals of the density. Most results to date have been obtained in the framework of independent sampling, but current research directions motivated by applications consider nonparametric functional estimation under various types of dependence.

The list of the invited speakers includes:
A. Baron, R. Beran, A. Berlinet, P Burman, R. Eubank, R. Fraiman, A. Feuerverger, I. Gijbels, W Gonzalez-Manteiga, L. Gyorfi, N. Heckman, E. Isogai, A. Krzyzak, R. C. Liu, G. Lugosi, B. MacGibbon, J. S. Marron, E. Masry, H. Mueller, D.-T. Pham, J. Ramsay, J. Rice, P Robinson, J. Rojo, U. Stadtmueller, L. T Tran, Y. Truong, F. Udina, J.-L. Wang, S. Yakowitz, B. Yu.

Workshop on Empirical Bayes and Likelihood Inference

9-15 November 1997
Org.: S. Ejaz Ahmed (Regina) and Nancy Reid (Toronto)

Empirical Bayes and likelihood-based methods continue to play vital roles in statistical inference. Empirical Bayes/shrinkage estimation and meta-analysis provide extremely useful techniques for combining data from various sources. Asymptotic theory has advanced understanding of the fundamental role of the likelihood function. This workshop will explore connections between empirical Bayes methods and likelihood inference, with emphasis on recent developments and their application in various fields.

The list of the invited speakers includes:
J. O. Berger, J. Bernardo, D. R. Cox*, B. Efron*, D. Fraser, E. George*, M. Ghosh, V Godambe, I. Guttman, D. Kalbfleisch*, T. A. Louis, B. MacGibbon, J. N. K. Rao, C. Roberts*, E. Saleh, K.P Sen, B. K. Sinha, D. Stephens, L. Wasserman*, J. Zidek.

Workshop on Time Series Analysis

23-27 March 1998
Org.: Roch Roy (Montréal)

Time series analysis continues to be a subject of major interest in statistics since almost every scientific discipline is concerned with data collected over time. This workshop will focus on recent developments in nonlinear and nonparametric methods.

The list of the invited speakers includes:
D. R. Brillinger, D. Guegan, M. Hallin, K. Knight, A. Latour, D.-T. Pham, B. W Silverman*.

Lecture Series on Recent Advances and Trends in Spatial Statistics

23-24 March 1998
Speaker: Noel A. C. Cressie

Workshop on Image Analysis

30 March - 3 April 1998
Org.: Marc Moore (École polytechnique)

In many applications data come in the form of images. Often these observations reveal a stochastic behaviour in the image. Appropriate stochastic models are needed to represent these stochastically generated images. Also, the statistical tools used to analyse these data must be able to take into account the morphological character of the image. This workshop

plans to present results to deal with these problems, and also illustrations of their use.

The list of the invited speakers includes: S. Geman, P. J. Green, H. Kunsch, M. Schmitt, Laurie Yates.

Workshop on Statistical Inference for Spatial Processes

6-9 April 1998
Org.: Xavier Guyon (Paris I)

It is known that many of the tools for statistical inference developed in the context of independent data, or in the context of standard one-dimensional stochastic processes, are not applicable to spatial processes. In this workshop we plan to present recent results pertaining to statistical inference for some important classes of spatial processes, e.g. Markov random fields, random set processes. The inference tools considered will include those based on simulations.

The list of the invited speakers includes: F. Comets, B. C. Gidas, J. L. Jensen, J. Moller, L. Stein.

Workshop on Applications of Spatial Statistics in Earth, Environmental and Health Sciences

27 April - 1 May 1998
Org.: Richard Lockhart (Simon Fraser)

This workshop will look at techniques in spatial statistics applied to a variety of applied problems in the earth, environmental, and health sciences. Spatial covariance modelling, applied to meteorological problems such as acid precipitation, to environmental problems such as spatial distribution of cancer and related problems will be a focus but other applications in the earth, environmental, and health sciences will be looked at.

The list of the invited speakers includes: D. Billheimer, P. Diggle*, P. Guttorp, P. Sampson, R. L. Smith, J. Zidek.

Workshop on Statistics and Epidemiology

3-9 May 1998
Org.: Gerarda Darlington (Toronto) and Shelley Bull (Toronto)

This workshop will look at recent developments in descriptive epidemiology, etiologic studies, and clinical epidemiology.

The list of the invited speakers includes: N. E. Breslow*, A. Donner, N. Kreiger, J. Neuhaus.

Workshop on Genetic Epidemiology

9-16 May 1998
Org.: Gerarda Darlington (Toronto) and Ken Morgan (McGill)

A discussion of statistical and genetic principles (segregation analysis, linkage analysis, association analysis, population genetics, isolated populations, linkage disequilibrium mapping) and complex pedigrees and complex traits (gene identity by descent families, gene identity by descent individuals).

The list of the invited speakers includes: R. Elston, J. Ott, N. Risch*, E. Thompson, Bruce Weir, W. Whittemore, E. Wijsman*.

Workshop and Symposium on Longitudinal Data Analysis for Complex Surveys

18-22 May 1998, Statistics Canada, Ottawa
Org.: Michael Hidiroglou (Statistics Canada), Sylvie Michaud (Statistics Canada), David Binder (Statistics Canada)

Longitudinal data analyses are increasingly used in the social sciences in the past decade. The tools for this type of analysis include event history methods, gross flows, conditional and marginal models, and hierarchical linear modelling. These techniques have been developed without taking into account complex surveys. This workshop will focus on recently developed methods in longitudinal data analysis and in particular on the required adjustments for use for data arising from complex surveys.

Workshop on Event History Analysis

25-29 May 1998
Org.: Richard J. Cook (Waterloo) and Jerry F. Lawless (Waterloo)

Event history analysis is now commonly applied in most branches of science, including demography, epidemiology, medicine, engineering, and economics. The purpose of this workshop is to stimulate a critical appraisal of existing models and techniques and to consider future developments.

The list of the invited speakers includes: O. O. Aalen, P. K. Andersen, V. T. Farewell, J. D. Kalbfleisch, N. Keiding, J. P. Klein, S. W. Lagakos, D. Lin, R. J. A. Little, S. A. Murphy, David Oakes, R. L. Prentice, B. W. Turnbull, L. J. Wei.

Workshop on Statistics of Brain Mapping

13-14 June 1998
Org.: Keith Worsley (McGill)

The theory of random fields, image analysis and multivariate statistics is finding new applications in the rapidly emerging area of brain mapping by Positron Emission Tomography (PET) and functional Magnetic Resonance Imaging (fMRI). This two-day workshop, to be held after the 4th International Conference on Functional Mapping of the Human Brain to be held in Montréal, June 7-12 1998, is designed to bring together statisticians interested in image analysis, and researchers interested in brain mapping.

The list of the invited speakers includes:

R. Adler, F. Bookstein, E. Bullmore, B. Eddy, K. Friston, U. Grenander, N. Lange, R. McIntosh, M. Miller, J.-B. Poline, D. Siegmund, P. Thompson, S. Zeger, K. Zilles.

Extra-thematic activities 1997-1998

Here is a list of scientific events to be held in parallel to the theme year. The descriptions are taken from the proposals submitted to the CRM Advisory Committee.

International Linear Algebra Society Symposium on Fast Algorithms for Control, Signals and Image Processing

6-8 June 1997, Winnipeg
Org.: P. N. Shivakumar (Univ. of Manitoba)

The Symposium emphasizes modern methods in scientific computing and linear algebra relevant to digital control, signal and image processing. For such applications it is important to consider ingredients such as:

(i) sophisticated mathematical models of the problems, including a priori knowledge,
(ii) rigorous mathematical theories to understand the difficulties of solving problems which are often ill-posed, and
(iii) fast algorithms for either real-time or data-massive computations.

Aspects of each of these three ingredients will be discussed by the speakers.

Canadian Undergraduate Mathematics Conference

18-21 July 1997, Univ. de Montréal
Org.: J. Marcil (Chair), E. Pelletier, L. Corbeil, P. Larocque, Y. Delbecque

The CUMC gives Canadian students the opportunity to share ideas and to open up to new career possibilities. Participants are invited to present a lecture, either on personal work or any mathematical topic connected to a contemporary mathematical challenge. Furthermore, a few lectures will be given by professors, most of them coming from the Montréal region.

CRM-Fields-CAP Summer Workshop in Theoretical Physics
Solitons: Properties, Dynamics, Interactions and Applications

20-26 July 1997, Queen's Univ.
Org.: B.C. Castel (Queens), R. B. Mackenzie (Univ. de Montréal), M. B. Paranjape (Univ. de Montréal), W. J. Zakrzewski (Durham)

Recent work on topological solitons and like objects has given rise to interesting results in both mathematics and physics. Mathematical applications include integrable models, the classification of 3- and 4-manifolds, which has been related to soliton solutions of instanton and BPS monopole equations, etc. Physical applications include particle and nuclear physics (monopoles and skyrmions), solid state physics (vortices in superconductors, baby skyrmions in the quantum Hall effect, etc.), phase transitions, magnetostatics and ferromagnetodynamics, cosmology, etc. The workshop will bring together researchers from the following fields: BPS solitons and *s*-duality, soliton scattering, electroweak strings, baby skyrmions and applications to solid state, skyrmions and applications to nuclear physics, nontopological solitons.

Workshop on Differential Equations

21-25 July 1997 (tentative), Dalhousie
Org.: Alan Coley (Dalhousie)

This workshop will take place during the week preceding the international conference in differential equations held in Halifax during the week of July 25-29 and will emphasize geometric techniques. Three series of lectures are planned.

International Conference on Differential Equations with Applications to Biology

25-29 July 1997, Dalhousie Univ.
Org.: S. Ruan (Dalhousie), G. Wolkowicz (McMaster), J. Wu (York)

The theory of differential equations and dynamical systems has advanced significantly, and various applications have been found in biology, chemistry, ecology, engineering, epidemiology, industry, medicine, neurobiology, oceanography, physics, physiology, psychology, zoology, and many other fields. The subject is of increasing importance, as witnessed by the current interest in population dynamics, neural computations, genetic algorithms, and similar subjects.

The plenary lectures feature current research in epidemiology (P. van den Driessche and G. Webb), physiology and neurobiology (L. Glass, M. Hirsch and M. Mackey), population dynamics (S. Levin, L. Segel, H. Smith and P. Waltman), and qualitative analysis (J. Mallet-Paret and K. Schmitt).

Conférence à la mémoire de Gilles Fournier

13-16 August 1997, Univ. de Sherbrooke
Org.: M. Frigon (Univ de Montréal), A. Granas (Univ. de Montréal and U. Nicolas Copernicus) and T. Kaczynski (Univ de Sherbrooke)

This is a memorial conference for the second anniversary of Gilles Fournier's death. Four commemorative conferences will be delivered. The lecturers will be A. Granas, Mario Martelli (California SU-Fullerton), Jean Mawhin (Louvain), Michel Willem (Louvain). There will be also eight plenary lectures.

12th Summer Conference on Topology and its Applications, and Workshop on Continuum Theory, Set-Theoretic Topology and Applied Topology

12-16 August 1997, Univ. of Nipissing (North Bay)
Org.: Stephen Watson (York)

The scientific scope of these summer meetings is traditionally quite broad. It has been decided to maintain this practice but to emphasize three important areas within topology. The event will do this by offering workshops consisting of a series of lectures in each of these topics. The three mathematicians invited to give these lectures are doing some of the best current work. All three are quite young. They are Kazuhiro Kawamura of Tsukuba University who has worked extensively in continuum theory and geometric topology, Stevo Todorčević of Beograd University and University of Toronto, who is the leading figure in applications of partition relations to set-theoretic topology, and Dmitri Shakhmatov of Moscow State University and Ehime University, who is a key figure in applied topology.

First Vancouver Meeting in Probability

19-28 August 1997, UBC
Org.: Martin Barlow and Ed Perkins (UBC)

This two-week workshop will consist of 6 minicourses on various applications of probability. Each minicourse will consist of four one-hour lectures. The speakers and their titles are: R.T. Durrett (Cornell), *Stochastic spatial models*; H. Foellmer (Berlin), *Probabilistic Problems in Finance*; T. Kurtz (Univ of Wisconsin), *Infinite systems of stochastic differential equations*; J.-F. Le Gall (Paris VI), *Superprocesses, Markov snakes and partial differential equations*; C.M. Newman (NYU), *Random geometry of first passage percolation*; D.W. Stroock (MIT), *Applications of analysis on pathspace*.

Theme Year 1998-1999: Number Theory

Org.: H. Darmon (McGill), M. Goresky (Institute for Advanced Study), F. Murnaghan (Toronto), K. Murty (Toronto), R. Murty (Queen's)

Overview

Number theory lies at the heart of mathematics and in fact goes under the appellation of 'Queen of Mathematics.' It has provided the source of research problems that have given rise to fundamental concepts in many parts of mathematics. The CRM thematic year 91-92 was related to number theory and was organized by Ram Murty. Earlier, during the spring of 1988, Robert Langlands and Dinakar Ramakrishnan held a workshop at the CRM on the zeta functions of Picard modular surfaces. Both the thematic year and the workshop were extremely successful, not only in terms of the number of participants and of their quality, but also of their legacy: four important publications came out of them (*Elliptic Curves and Related Topics*, CRM Proceedings and Lecture Notes, Vol. 4; *Theta Functions*, CRM Proceedings and Lecture Notes, Vol. 1; *Introduction to Abelian Varieties*, Kumar Murty, CRM Monograph series, Vol. 3; *The Zeta Functions of Picard Modular Surfaces*, eds. R. P Langlands, D. Ramakrishnan, Les Publications CRM) and several recent results can be traced back to them.

Recently, Andrew Wiles using the work of Kenneth Ribet resolved the 350 year old problem of Fermat's Last Theorem. His work has opened the door of a new universe of methods that needs to be understood, simplified and explained so that further problems may be solved. It is the aim of the CRM thematic year 98-99 to address this need. It is expected that there will be active participation of the many number theorists from across Canada as well as their postdocs and students.

The format of the year puts the emphasis on both research *and* teaching. Number theory is an extremely wide area and most universities cannot offer as many courses as needed to provide young students with a sound basis. It was consequently judged that the usual format of several short workshops would not be ideal. Instead the organizers opted for the following format: five one-month courses given for the benefit of graduate students and postdoctoral fellows intertwined with four workshops. The courses will cover:

(i) Elliptic curves and automorphic forms,
(ii) Representations of *p*-adic groups,
(iii) Automorphic L-functions,
(iv) *p*-adic L-functions,
(v) Algebraic Cycles and Shimura Varieties.

The four workshops will be devoted to:

(i) Arithmetic algebraic geometry,
(ii) L-functions and related themes,
(iii) *p*-adic L-functions and modular forms and
(iv) Representations of *p*-adic groups.

The workshops will follow the various courses that they are connected with. Since the topics of elliptic curves, automorphic forms, and automorphic L-functions are closely connected, there will be only one workshop related to these courses. The optimal timetable has not yet been determined. Two major events will be added to these "course-workshop" cycles. They are the CRM Summer School at Banff (May 11-20, 1998, Orgs.: J. Lewis with B. Gordon, S. Mueller-Stach, S. Saito, N. Yui) and the Sixth Conference of the Canadian Number Theory Association (CNTA) that will be held during the summer of 1999 in Winnipeg (org.: H. Williams).

8th CRM Summer School at Banff: *The Arithmetic and Geometry of Algebraic Cycles*

11-20 May 1998, Banff (Alberta)

Org.: J. Lewis (Univ of Alberta) with B. Gordon (Univ. of Oklahoma), S. Mueller-Stach (Univ. Essen), S. Saito (Univ of Tokyo), N. Yui (Queen's)

The purpose of the Summer School is to offer a full and in-depth account ranging from introductory courses on the subjects by leading experts to discussion of the latest developments in the fields.

As a subfield of algebraic geometry, the subject of algebraic cycles has thrived through its energetic interaction with algebraic K-theory, Hodge theory, arithmetic algebraic geometry, number theory, and topology (as in Lawson homology). These interactions have led to such developments as: a description of Chow groups (cycle groups) in terms of algebraic K-theory; the application of the Mercurjev-Suslin theorem to the arithmetic Abel-Jacobi mapping, with corresponding torsion results for Chow groups; progress on the celebrated conjectures of Hodge, and of Tate, which "compute" cycle class groups respectively in terms of Hodge theory or as the invariants of a Galois group action on étale cohomology; the conjectures of Bloch

and Beilinson, which "explain" the zero or pole of a variety's *L*-function, as well as interpret the leading non-zero coefficient of its Taylor expansion at a critical point in terms of arithmetic and geometric invariants of the variety and its cycle class groups. The immense recent progress in algebraic cycles, based on interaction with many areas of mathematics (not unlike algebraic geometry itself), has contributed to a considerable degree of inaccessibility, especially for graduate students and non-specialists. Even specialists in one approach to algebraic cycles may not understand other approaches well.

To our knowledge, this would be the first conference to focus on the arithmetic and geometry of algebraic cycles, bringing together experts who approach this topic from different directions. Other conferences, such as the Motives conference (Seattle 1991) or conferences on Arithmetic Algebraic Geometry or Algebraic K-theory, overlap with the topic of this conference, but have a more narrow perspective.

The featured speakers will give 3 lectures each. All are confirmed except those marked by an asterisk who have agreed tentatively. They are: Spencer Bloch, J.-L. Colliot-Thelene*, Mark Green, Uwe Jannsen, Blaine Lawson, Dinakar Ramakrishnan, Shuji Saito, Don Zagier. Other major speakers (1 lecture) include: A. Beilinson, Ch. Deninger, E. Friedlander*, H. Gillet, B. Gordon, B. Gross*, J. Lewis, S. Muellr-Stach, K. Murty, J. Nekovar*, W. Raskind, Masahiko Saito, Takeshi Saito, C. Schoen, A. Scholl, C. Soule, A. Suslin*, V. Voevodsky, N. Yui, Y. Zarhin.

Courses: *Elliptic Curves and automorphic forms; Automorphic L-functions;* Workshop: *L-functions and related themes*

The course on elliptic curves and automorphic forms will be given in three parts by Kumar Murty and Ram Murty, and Henri Darmon as a two-month course. This should be in the fall of 1998 and will cover the basic material in the theory of elliptic curves. Henri Darmon will give a quick survey, based on his 'Russian Math Surveys' article on the proof of the Shimura Taniyama conjecture à la Wiles, etc.

The second course will be on analytic aspects of automorphic L-functions and will be given by Ram Murty. The topics to be covered will be Hecke theory, Eisenstein series, L-functions of GL(n) and converse theory.

Course and Workshop: *Representations of reductive* p*-adic groups*

The course, given by Fiona Murnaghan, will be divided into two parts. The first part will include an overview of characters of admissible representations and orbital integrals. Results relating characters and orbital integrals will be discussed. One such result is Harish-Chandra's local character expansion, which expresses certain character values as linear combinations of Fourier transforms of nilpotent orbital integrals. It will summarize recent results concerning the coefficients and the domain of validity of the expansion. It will also give a general description of some conjectures and open problems.

The second part of the course will consist of a survey of recent work on K-types for p-adic groups. This is the study of admissible or, more generally, smooth representations of reductive p-adic groups via their restriction to compact open subgroups. It will indicate how certain K-types are defined in terms of filtrations of parahoric subgroups, and discuss results of Moy and G. Prasad on properties of these K-types and the admissible representations which contain them. The work of Bushnell and Kutzko on classifying smooth representations via K-types will also be described.

Course and Workshop: p*-adic L-functions*

Henri Darmon will explain recent progress in the theory of p-adic L-functions associated with the cohomology of algebraic varieties, with special emphasis on elliptic curves and modular forms. In particular, he will discuss the main conjectures of Iwasawa theory for modular elliptic curves. Two settings for the main conjecture (for non-CM curves) have been explored so far: the first corresponding to the cyclotomic Z_p-extension of Q, and the second to the anticyclotomic extension of a quadratic field. He will discuss the work of Kato which gives a partial proof of the main conjecture in the cyclotomic case, and the work of Bertolini and himself which leads to similar results in the anticyclotomic case. The relation with the deformation theory of Galois representations will be discussed.

Course and Workshop: *Algebraic Cycles and Shimura Varieties*

There will be two courses in this area, one by Kumar Murty and another by Mark Goresky. Kumar Murty will give a two-week course on "The Hodge and Tate Conjectures" in the spring of 1999. These conjectures will be related to various conjectures about zeros and poles of zeta functions associated with varieties. Mark Goresky will give a course on "Compactifications and Cohomological Methods." It will concentrate on the real and complex geometry and topology of the various compactifications which are associated with Shimura varieties:

(i) locally, Hermitian and linear locally symmetric spaces and compactifications (Borel-Serre, reductive Borel-Serre, Baily-Borel Satake and toroidal),

(ii) group, L_2, intersection and weighted cohomologies,

(iii) Hecke operators, the geometry of a Hecke correspondence, the induced correspondence on the boundary, counting fixed points, Lefschetz number of a Hecke correspondence.

A one week workshop in this area will follow.

6th Conference of the CNTA

The Canadian Number Theory Association (CNTA) was founded in 1987 at the International Number Theory Conference at Laval University. Later meetings were held in Banff (1988), at the University of British Columbia (1989), Queen's University (1991), Dalhousie University (1994), and Carleton University (1996). In keeping with the objectives of the CNTA of enhancing and promoting research in Number Theory across the country, the next international CNTA meeting will be held in Winnipeg during the Summer of 1999. It will be the conclusion of the CRM thematic year. The organizer is H. Williams (Manitoba) and the scientific committee for the conference consists of J. Borwein (SFU), D. Boyd (UBC), C. David (Concordia), R. Murty (McGill/Queen's), C. Stewart (Waterloo) and H. Williams (Manitoba).

The week long event will welcome 5 main speakers, about 20 invited speakers, and several contributed talks divided into a maximum of 3 parallel sessions. Five specific themes have been chosen by the organizers. These areas have seen rapid development in recent years, both in Canada and internationally. They also represent the interests of the members of the scientific committee. These themes are:

(i) Mahler's Measure and L-functions;

(ii) Computational Combinatorial Number Theory;

(iii) Diophantine Approximation;

(iv) Arithmetic Algebraic Geometry;

(v) Computations and Curves.

Extra-thematic activities 1998-1999

The general scientific program for the year 98-99 will be decided by the CRM Advisory Committee during the Fall of 1997. At this point funds have been committed to the following three events.

Congrès de la Société Statistique du Canada

31 May - 3 June 1998, Univ. de Sherbrooke
Org.: Louis-Paul Rivest (Univ. Laval)

The theme of the 1998 annual congress of the SSC will be "From Sampling to Data Analysis." It will be held jointly with the yearly meeting of French-speaking statisticians, "Méthodes et applications de la statistique."

Formal Power Series and Algebraic Combinatorics '98

5 days in June 1998, Fields Institute
Org.: N. Bergeron (York, chair), M. Delest (Univ de Bordeaux), F. Sottile (Toronto), W. Whiteley (York)

The relationship between algebraic and enumerative combinatorics, and computer science is very deep. On the one hand, complexity problems in computer science rely on counting techniques. Also, the development of efficient algorithms often depends on the understanding of some combinatorial structures: graphs, posets, matroids, polytopes, etc. On the other hand, combinatorialists are heavy users of computers for computations and visualisation of objects. Both aspects of this relationship are featured in FPSAC conferences.

The meeting will also consider the applications of algebraic combinatorics to other fields. To mention a few:

(i) finite geometry in connection with posets, polytopes, and oriented matroids,
(ii) algebraic geometry using combinatorial models to describe (co)homology of certain varieties or to give computational algorithms,
(iii) homology via posets (shellable, Cohen-MacCauley, etc.),
(iv) physics (symmetric polynomials with parameters are eigenvalues of physical model operators),
(v) statistical physics via enumeration of polyominos, stacks of pieces, animals, etc.

International Federation for Information Processing Symposium *Modelling and Control of Distributed Parameter Systems: towards 2000*

(tentative title)
10-14 August or 17-21 August 1998, Montréal
Org.: Michel Delfour (Univ. de Montréal)

Theme Year 1999-2000: Mathematical Physics

Overview

In view of the remarkable advances that are taking place in mathematical physics and of their striking impact on mathematics and physics, it was decided to devote the 1999-2000 theme activities at the CRM to this area.

The plan is to have a broad coverage with a wide range of activities: an extended program on integrable models and statistical systems, various workshops, mini-courses, etc.

The year will be coordinated by Yvan Saint-Aubin and Luc Vinet. A good number of people have already agreed to contribute to the organization of the year. The planned activities will include:

- Concentration period on integrable models and statistical systems. Org.: Ph. Di Francesco (Univ. of North Carolina and Saclay), J. Harnad (Concordia), A. LeClair (Cornell), P. Mathieu (Laval), P. Winternitz (CRM)
- Workshop on general relativity, astrophysics and cosmology. Org.: E. Poisson (Guelph)
- Workshop on Schrödinger operators and atomic physics. Org.: L. Seco (Univ. of Toronto)
- Workshop on Quantum Information Theory. Org.: G. Brassard (Univ. de Montréal)
- Workshop on the theoretical aspects of supraconductivity. Org.: A.-M. Tremblay (Univ. de Sherbrooke)
- Workshop on String Theory and Quantum Geometry. Org.: D. H. Phong (Univ. Columbia)
- CRM Summer School in Banff. Org.: Y. Saint-Aubin, L. Vinet

RESEARCH PROGRAMS

Square Integrable Group Representations and Wavelets
Twareque Ali

Twareque Ali's research during the year 1996-97 was centred around the theory of square integrable group representations and their applications to wavelet analysis. Specifically, using representations of the full Poincaré group, a class of wavelet-like transforms has been constructed, which were subsequently used to develop remarkably fast algorithms for analysing two and three-dimensional images. On the theoretical side, a generalization of the classical theorem on the square-integrability of group representations has been obtained which incorporates vector coherent states and square integrability modulo a subgroup. The extended theorem has applications to the theory of matrix-kernels appearing in Hilbert spaces of holomorphic functions of several variables.

Numerical methods for nonlinear hyperbolic systems
Paul Arminjon

P. Arminjon's main research interest lies in the domain of numerical methods for nonlinear hyperbolic systems, with applications to engineering problems in gas dynamics and electrostatics/electrodynamics. For transonic/supersonic compressible flows, P. Arminjon studies, with his collaborators, A. Dervieux and M. C. Yallon, the design and numerical analysis of high accuracy finite difference, finite element or finite volume methods, and their application to typical flows arising in aerodynamics and aerospace engineering. Recently, they have obtained a family of non-oscillatory 2nd-order accurate schemes based on:

(i) a 2-step finite volume Richtmyer-Galerkin scheme with a TVD-controlled artificial viscosity,

(ii) a TVD-controlled barycentric combination of the Richtmyer-Galerkin and Osher's first order scheme,

(iii) a 2nd-order version of Osher's scheme using MUSCL-extrapolated, TVD-controlled, cell-interface flux values, and

(iv) a new finite volume extension, for 2-dimensional conservation equations, of the Nessyahu-Tadmor non-oscillatory 1-dimensional centred difference scheme.

In joint work with M. C. Yallon, they have recently proved the convergence of this latter scheme for a linear conservation equation, and they are presently extending the proof to the nonlinear case.

Nonlinear delayed equations
Jacques Bélair

Nonlinear dynamics gives an interpretation of complex changes in physiological rhythms (as bifurcations) when the values of the control parameters are modified. The theory leads to predictions for the possible behaviours in experimental settings and gives a unified explanation for the various regimes. Bélair's work has concentrated on nonlinear delayed feedback in control and in hormonal and neuromuscular system oscillations, stressing the role of the delay, the multiple feedback loops and the variable delays in the generation of periodic (oscillatory) or irregular behaviours.

Systems of neural networks of small size were analysed, with an emphasis on the combined role of time delays incorporated into the model to take into account processing time and the architecture of the network, with a view to establishing the deleterious effects of the delays.

In collaboration with J. Mahaffy and M. Mackey a model for erythropoiesis was developed which incorporates a constant rate destruction mechanism. This work is ongoing, with an attempt to incorporate recent discoveries on thrombopoietin.

Together with researchers in pharmacology, a project was started with a view to building models which incorporate transient regimes in their representations of absorption mechanisms.

Machine Learning Algorithms
Yoshua Bengio

Machine learning algorithms allow a computer to learn from examples. This field of research is at the intersection of artificial intelligence, statistical inference, and numerical optimization. Learning algorithms are particularly useful when we don't have enough explicit knowledge about a problem in order to directly write a program that solves it, but where enough examples illustrating the task to perform are available. In this context, learning means choosing a function from a set of functions according to the expectation of a criterion (the quality of the solution found by the computer on a particular example). However, since the true probability distribution of the examples is unknown, this expectation cannot be computed, only approximated by its empirical value on the observed data. The real difficulty of learning is

therefore to generalize, i.e., to transfer information from the observed data to new cases. The research of Yoshua Bengio is focused on certain types of learning algorithms (in particular, artificial neural networks, and hidden Markov models) and their applications (to pattern recognition, speech recognition, computer vision, monitoring industrial processes, and prediction and decision taking from financial time-series).

Algebraic combinatorics
Nantel Bergeron

Nantel Bergeron works in three main areas:

A) Schubert polynomials: together with F. Sottile, he is considering the structure constants of the cohomology of flag varieties.

B) The n! conjecture and MacDonald polynomials: with F. Bergeron, M. Haiman, A. Garsia and G. Tesler he is attempting to give a proof of a conjecture of Haiman and Garsia concerning families of harmonic polynomials in two sets of variables. This would prove the positivity of MacDonald's symmetric polynomials. (This was the subject of a workshop he co-organised at the CRM in May of 1997.)

C) Descent algebras: jointly with S. van Willenberg, he is currently pursuing his work on this topic, in particular on the type D case.

Algebraic transformation groups and algebraic geometry
Abraham Broer

Abraham Broer is primarily interested in connections between algebraic geometry and representation theory. He currently studies decomposition classes: these are subvarieties of a semisimple Lie algebra with elements having similar Jordan normal forms. In this study, interesting variations of determinantal varieties and cotangent bundles of flag varieties come up.

Important tools in this study are the various vanishing theorems he proved for the higher sheaf cohomology and Dolbeault cohomology of vector bundles on spaces like the cotangent bundle of a flag variety.

Applications are in normality problems of nilpotent varieties; in the structure of rings of differential operators on homogeneous spaces, in particular their multiplicities and PRV-determinants; in Springer's representations of the Weyl group on cohomology groups; and in the combinatorial theory of the hyperplane arrangements coming up in Lie theory.

A different interest lies in invariant theory. He recently found some basic results on the invariant theory of finite groups acting over a field of positive characteristic.

Control and nonsmooth analysis
Francis Clarke

A recent paper [IEEE Transactions on Automatic Control 42 (1997) 1394-1407] written in collaboration with Yu. S. Ledyaev, E. Sontag and A. Subbotin solves a well-known and long-standing question in control theory: we give a constructive proof of the fact that any asymptotically controllable system admits a retour d'état which stabilises it. In general, it is necessary that this retour d'état be discontinuous. One can then prove its robustness by some new and apparently very promising techniques, and establish interesting relationships with the regularity of eventual Liapunov functions.

Shape optimization, intrinsic differential geometry and the theory of thin shells
Michel Delfour

PROJECT 1: SHAPE OPTIMIZATION, INTRINSIC DIFFERENTIAL GEOMETRY, AND ASYMPTOTIC THEORY OF THIN SHELLS

The central theme of this research program is the optimization with respect to the shape or the geometry of a domain on which is defined a or a system of partial differential equations. This type of problem is generic in shape and structural optimization (aeronautics, thermal problems, image processing, etc.). At the theoretical level it is necessary to give a meaning to derivatives with respect to the shape and construct appropriate topologies on families of subsets. Among these, topologies induced by distance functions or families of functions parametrised by sets and embedded in a function space are of special interest. For instance, the algebraic distance function provides a very nice tool for the differential calculus on differential submanifolds. It makes it possible to deal with the theory of shells in a completely intrinsic fashion and extend the shape calculus to differential equations on submanifolds.

In a first step we have been able to give a completely intrinsic theory of thin shells for polynomial models. This led to the development of an intrinsic theory of Sobolev spaces on $C^{1,1}$ submanifolds of R^N as well as to the associated functional analysis and

the analogues of the classical inequalities (Korn, Poincaré, etc.).

In a second step, we have developed intrinsic tools to deal with the asymptotic problem (singular perturbation with respect to the thickness). Each polynomial model converges to an asymptotic model which is a coupled system of two equations: a membrane equation and a bending equation. For the P(2,1) model we recover the asymptotic equations generally accepted in mechanics. However we get the general case in which a new coupling term appears in the bending equation. This generalizes the two known cases: the plate and the bending dominated case. The new coupling term involves the mean curvature and the membrane energy, both zero in the so-far-known cases.

Within this program, A. Raoult (Grenoble, France), M. Bernadou (Pole Léonard de Vinci and INRIA, France) and M. Fortin (Laval) visited the CRM. The doctoral student J. Zhao (McGill) has completed his Doctoral thesis on the intrinsic theory of nonlinear shells and the Master student S. Roy (Montréal) works on the construction and approximation of submanifolds from distance functions. This constitutes an essential step in the optimal design of shells.

PROJECT 2: NUMERICAL METHODS IN IMPULSIVE DIFFERENTIAL EQUATIONS

In order to preserve some accuracy, the solution of impulsive differential equations is usually approximated by low order variable step methods where the discretization nodes are chosen at the occurrence of impulses. In impulsive control problems this typically leads to a slow progression of the method or even a standstill when a train of impulses has an accumulation point. Joint work with F. Dubeau (Sherbrooke) has led to the use of high-order one step methods on a fixed node discretization. Despite the fact that the solution is at most of bounded variation (not even continuous), we obtain a nodal convergence rate which linearly increases with the order of the approximation scheme. We theoretically and numerically show that the predicted orders are optimal. This goes against the established perception that when the solution is nonsmooth, the order of the error cannot be improved by going to higher order schemes. So these results provide an interesting approach to impulsive control problems which typically occur in aeronautics.

PROJECT 3: NUMERICAL METHODS FOR THIN SHELLS

The numerical approximation of the solution of thin shells represents an important international research activity and an even more important part of the software development business for structures. There is also an urgent need for models and methods to handle multilayer shells made of composite materials or shells controlled by piezoelectric sensors and actuators. A specific GIREF based project for the design of the body of all-purpose vehicles is in the planning phase. (GIREF is the *Groupe Interdisciplinaire de Recherche en Éléments Finis*.)

Cooperation has been initiated with M. Fortin (Laval) in an effort to combine the numerical and software development expertise of the GIREF and the new intrinsic tools developed in Montréal. Thanks to a CRM-CERCA postdoctoral student, Gen Yang, the program is now progressing well.

One critical problem in the approximation of thin shells is the numerical locking phenomenon which partly arises from the fact that we are dealing with a singular perturbation problem. F. Brezzi (Pavia, Italy), D. Arnold (Penn. State, USA) and their collaborators have found a clever and constructive way to get around this difficulty for plates. We have been able to show that the constructions extend to thin shells and that a whole family of mixed locking-free methods can now be used. Yet these techniques are also strongly dependent on the knowledge of the asymptotic system. As we have now identified the general asymptotic model, it becomes possible to adapt this work to still problematic cases. Other types of approximations are also currently being considered.

Fractional generalization of the KdV equation
Stéphane Durand

Using supersymmetry it is possible to generalize in a non-trivial way the Korteweg-de Vries equation (KdV) to an integrable system of two coupled differential equations (Mathieu). Knowing that the supersymmetry can itself be extended (parasupersymmetry and fractional supersymmetry [Durand, Vinet]), it is natural to look for generalizations to integrable systems of several coupled differential equations. The formalism of fractional superspace introduced by Durand allows such a generalization in a natural way. This result is reached using the fractional extension of supersymmetry, the Hamiltonian structure of the fractional pseudo-classical mechanics and the fractional generalization of superextension of Virasoro algebra (and/or its q-deformations).

Values omitted by classes of univalent functions
Richard Fournier

Richard Fournier and his collaborator (St. Ruscheweyh) are working at describing explicitly the values omitted by various normalized classes of univalent functions on the unit disk in the complex plane. It seems that these values might be described in simple terms by certain combinations of Taylor coefficients of the functions. Moreover it appears that the omitted values characterize, in a certain sense, various classes of univalent functions, for example the convex ones. This work had led to new inequalities on Taylor coefficients and the modulus of convex conformal transformations. It is hoped that these results can be used to solve some problems on homographic transformations of convex univalent functions.

Quantum groups, W-algebras and deformations
Luc Frappat

Anyons are two-dimensional objects exhibiting fractional statistics, whose exchange properties are governed by the braid group rather than the permutation group. These anyonic structures seem to be a natural framework in which to realise the usual quantum groups and their supersymmetric analogues. This was done during the year for the quantum unitary affine groups. Another project, joint with V. Hussin, was the classification of the quantum deformations of the supergroup Gl(1|1), using the technique of R-matrices.

In the study of integrable systems as well as in the classification of conformal field theories, W-algebras play a central role. Their q-deformations appear in the quantisation of systems such as the Calogero-Moser and the Ruijsenaars-Schneider models. Particular emphasis was placed on the clarification of the relation between elliptic algebras and q-deformations of W-algebras. This gave rise to several publications. In the same area, a joint project with L. Vinet concerned the application of finite W-algebras to the study of Lie algebras.

Critical points of multivalued functionals
Marlène Frigon

The critical point theory of continuously differentiable functionals and the set-valued analysis are two important and active domains in mathematics. Marlène Frigon's work is concerned with the development of a critical point theory for set-valued functionals. This theory will then be applied to partial differential inclusions.

Image processing & target recognition applied to aerial surveillance
Langis Gagnon

Langis Gagnon is principal specialist at Lockheed Martin Canada and is affiliated to the CRM. His research bears on the analysis of radar and infrared images and data fusion for airborne command and control systems. In accordance with LMC's mandate with the CRM, he helps to promote industrial research by co-supervising students, with, so far, four students of J. Patera and one $\mathbf{nc}m_2$ postdoctoral fellow having benefited from the opportunity. These students are working on enhancement of radar images by multiresolution filtering, extraction of characteristics in the infrared images of ships, the use of the Karhunen-Loeve transform as a tool for automatic recognition and multiresolution detection of military vehicles in radar images.

Artificial neural networks
Bernard Goulard

Bernard Goulard is in the third year of a NSERC-Industry partnership project. The purpose of this project is to extend the capacity of Atlantic Nuclear Services' monitoring and diagnosis systems by incorporating into them some Artificial Neural Networks (ANN). In collaboration with Y. Bengio, J-M. Lina and P. Turcotte, this has led to the implanting of a modular ANN based on a "mixture of experts," to classify the different regimes of a reactor. The distribution of the data densities was modelled by a parametrised mixture of Gaussians; the iterative EM (Expectation-Maximisation) algorithm was used, after having been modified to take into account the ambiguity attached to the classification of data. In collaboration with J-M. Lina, Bernard Goulard is also working on the application of wavelets to image processing; in fact, a one-year extension of the project is being requested from

NSERC to allow for the adaptation of the methods developed for teledetection. In another area, he is continuing his study, jointly with R. Roy and a student (A. Qaddouri), of parallel iterative processes in the solution of Boltzmann's equations of transport, and their applications to the characterisation of the distribution of neutrons in a reactor. They are now applying their methods to large scale problems (large spatial domains and numerous energy groups).

Symmetries and solutions of nonlinear systems
Michel Grundland

Michel Grundland's research in the last few years has dealt with symmetry-reduction methods and Riemann-invariant methods and their application to equations of nonlinear field theory, condensed matter physics, as well as fluid dynamics. The development of these methods has provided several new tools to study nonlinear phenomena in physics, especially those described by multidimensional systems of partial differential equations (pde) that were not solved by other methods (like inverse scattering). Grundland's research program can be divided into 4 projects:

(i) conditional symmetries for nonlinear pde systems;
(ii) comparison of the various methods based on Lie groups used to study pde's;
(iii) invariant solutions and partially invariant solutions of Navier-Stokes equations;
(iv) multiple Riemann waves for quasilinear pde systems and their relation to symmetry reduction methods.

Infinite Graphs and Graph Homomorphisms
Geňa Hahn

The research interests of Geňa Hahn lie in discrete mathematics. There are two main directions, infinite graphs and graph homomorphisms. The former includes mostly studies of ends in countable graphs (work with J. Širáň, Bratislava and F. Laviolette, Université de Montréal) and of infinite tournaments (in progress, with R. E. Woodrow, Calgary, and P. Ille, C.N.R.S. Marseille). There is also progress, with N. Sauer, Calgary, on the question of when a property of an infinite graph is also true for some finite subgraph including a given finite set. Graph homomorphisms are studied in the guise of the various chromatic numbers and in connection with the ultimate independence ratio of a graph. They are also treated in surveys (with C. Tardif, Bielefeld, published, and with G. MacGillivray, Victoria, in progress). Part of the interest is the potential application to design and communication algorithms in networks, a subject much studied in computer science. Related to this is also the revived interest in Cayley graphs as models of networks.

Classical and quantum integrable systems
John Harnad

During the past year, John Harnad's main research interest were all related to the modern theory of integrable systems. The topics studied were:

(i) isospectral deformations and classical *R*-matrices,
(ii) isomonodromic deformations and applications,
(iii) quantum integrable systems.

A recent work, in collaboration with A. R. Its, carries on the study of dual isomonodromic deformations, but also initiates a new program relating the latter to computation of correlation functions in integrable quantum and statistical models and the spectral distributions of random matrices, in which a special class of Fredholm integral operators arise, whose Fredholm determinants are the correlation functions in question. These are computed through the Riemann-Hilbert problem "dressing method," adapted to the case of isomonodromic deformations, leading to integral representations of importance in the calculation of asymptotics of such correlation functions. A key result derived in this work is the fact that the "dual" isomonodromic representations, deduced generally from the *R*-matrix structure, follow in this context from the invariance of the Fredholm determinant under Fourier transform of the integral kernel.

Geometry and physics
Jacques Hurtubise

Jacques Hurtubise' research work deals with geometrical and topological aspects of objects originating from mathematical physics. His projects are divided into two rather disjoint topics.

The first one studies the relationship between the solution spaces of several field equations of mathematical physics like those of the sigma model or Yang-Mills equations, and the functional spaces in which they lie. The questions are mostly topological in nature, like the proof of topological stability theorems. These theorems have been extended this year to the most general case known today. The solution spaces are here characterized as minima or critical sets of an

action functional, and the techniques used in the proofs involve also analytic subtleties from the calculus of variations.

The second one addresses the algebra-geometric properties of completely integrable mechanical systems. An invariant has been recently introduced that allows for a measurement of the complexity of a large number of these mechanical systems; whenever this complexity is minimal, the system possesses very natural coordinate systems that seem to be related to its quantisation.

Lie Supergroups & Quantum Deformations
Véronique Hussin

During the last twenty years, the theory of Lie groups and algebras has been extended in many directions. One of them deals with the supersymmetric theories and the notions of Lie supergroups and superalgebras. Since it is concerned with a unified description of fermionic and bosonic objects, one has to work with commuting and anticommuting variables. An interesting question deals with the resolution of nonlinear differential equations with such variables. V. Hussin, in collaboration with her student A. Ayari, has given an extension of the concept of symmetries for such equations and has obtained new invariant solutions.

Another theory developed along the last decade is the one of quantum groups, which are structures that appear in statistical mechanics, for example. Now, one deals with deformations of Lie groups by changing the type of the objects one is working with. A systematic method for investigating such deformations has been used for the non-semisimple Lie algebras. V. Hussin, in collaboration with L. Frappat, A. Lauzon and G. Rideau, has given a classification of the possible deformations of some 3 and 4 dimensional algebras.

Geometry of partial differential equations / quasi-exactly solvable systems
Niky Kamran

In joint work with Ian Anderson, Niky Kamran completed a detailed analysis of the cohomology of the variational bicomplex and the geometric integrability property for nonlinear hyperbolic differential systems in the plane. He also initiated with Thierry Robart the study of analytic Lie pseudogroups of infinite type as infinite-dimensional local Lie groups modelled on suitable locally convex topological vector spaces. Finally, he pursued his ongoing research projects with Peter Olver on quasi-exactly solvable spectral problems for differential operators, and with Keti Tenenblat on the Laplace transformation for submanifolds of projective space.

Algebraic geometry over groups
Olga Kharlampovich

Systems of equations over a group have been widely studied and are currently one of the main directions in combinatorial group theory. To approach Tarski's problem about the elementary equivalence of free groups of different ranks, it is necessary to study sets of solutions of equations over a free group. It is possible to transcribe into the theory of free groups, and more general torsion-free hyperbolic groups (in Gromov's sense), some basic elementary algebraic geometry and give analogies of notions of the Zariski topology, irreducibility and Hilbert's Nullstellensatz.

O. Kharlampovich indicates, in collaboration with A. Myasnikov, an algorithm to represent the set of solutions to an arbitrary system of equations over a free group as the union of a finite number of irreducible components in the Zariski topology (quadratic and multiquadratic equations play an important role here). They give a description of the irreducible components. They describe all finitely generated fully residually free groups as subgroups of groups obtained from a free group by a finite number of extensions of centralisers. As a result, they describe all groups that are universally equivalent to a free group.

Combinatorics & representation theory
Anatol N. Kirillov

During 1996-1997 Anatol Kirillov's primary interests have revolved around the interplay of representation theory of quantum groups and classical Lie algebras, algebraic geometry, combinatorics and exactly solvable models of statistical physics. In particular, the following results were obtained:

Algebraic geometry. Quantum cohomology of flag varieties and Schubert calculus. Construction and study of quantum Schubert and quantum Grothendieck polynomials, quantum Schur and quantum Macdonald functions. Algebraic construction of quantum cohomology ring of flag variety, and quantum

Orlik-Solomon algebra. New approach to classical and quantum Schubert calculus based on the study of certain non--commutative algebras. Proof of quantum Cauchy identity and quantum Pieri rule.

Representation theory and integrable models. Proof of the Macdonald conjecture on integrality of double Kostka coefficients. Description of spectral decomposition of integrable lattice models with applications to the representation theory of affine Lie algebras.

Combinatorics
Gilbert Labelle

Gilbert Labelle works in the area of algebraic combinatorics, in particular towards the development of a theory of asymptotic structures and a classification of combinatorial structures by their stabilisers. A particular structure he has considered is that of quadtrees and hyperquadtrees, studying their asymptotic properties and their statistical properties. Using symbolic computation, he is also developing the analysis of combinatorial species.

Groups and Lie algebras
John Labute

We are interested in the connection between groups and Lie algebras which was established by Wilhem Magnus. Each central series of a group gives a graded Lie algebra. This Lie algebra is very difficult to calculate in general. In the case of the lower central series of a free group we get a free Lie algebra — a result of Magnus and Witt. In the case of a group defined by a single relation we have determined the Lie algebra associated to the lower central series, in the case where the group is torsion free and the Lie algebra associated to the lower p-central series for p sufficiently large. The Lie algebras that we obtain are defined by a single relator and we determine the Poincaré series of these algebras.

These results are true also for pro-p-groups. Recently, with Helmut Koch and Suzanne Kukkuk, we have determined the Lie algebra associated to the lower central series of the Galois group of the maximal p-extension of a local field in the case $p \neq 2$.

In the above results the groups in question were of cohomological dimension 1 or 2. It would be interesting to extend our results to the case of a group of cohomological dimension 3.

Ising model on a lattice with boundary
Robert Langlands and Yvan Saint-Aubin

Partition functions for the Ising model on a two-dimensional lattice with boundaries depend on the state of the spin field at the boundary. For example, on a cylinder, the partition functions for both constant and free spin fields are known. But what are the partition functions for other boundary configurations? What are the relevant physical quantities at the boundary, i.e. those that have a limit as the size of the lattice goes to infinity? What are their distribution? Several physical arguments indicate that the critical behaviour of the Ising model is conformally invariant in the bulk. Does conformal invariance hold for physical properties at the boundary? In what sense? Robert Langlands and Yvan Saint-Aubin are exploring these questions using the theory of conformal fields and computer simulations.

Resampling Methods
Christian Léger

Christian Léger's research is on the use of resampling methods in statistics. These methods use the power of the computer to approximate the distribution of an estimator to construct, for instance, a confidence interval for an unknown parameter. To validate these methods, asymptotic theory as well as computer simulations are used. In the last few years, Léger has studied the use of resampling methods, such as the bootstrap and cross-validation, to choose a tuning parameter for nonparametric estimators. In a recent paper, it was shown that the rate of convergence of the estimator played an important role in the success of these methods in choosing the tuning parameter. More precisely, this paper explains why cross-validation works in choosing a tuning parameter when the problem is "hard," but does not when the problem is "easy."

Symmetry classes of polyominoes
Pierre Leroux

Polyominoes are important combinatorial structures for mathematical physics. They appear naturally in polymer models and the study of percolation. Recent work of the Bordeaux and Australian schools have given an enumeration with respect to area, perimeter and other finer parameters, for many classes of polyominoes having minimal convexity properties. In a geo-

metrical or combinatorial context, it is natural to consider convex polyominoes up to a reflection or a rotation, i.e. as objects free to move in space. Pierre Leroux is currently working at enumerating them, as orbits under the action of the dihedral group on convex polyominoes. Due to Burnside's lemma, this involves the enumeration of the various symmetry classes of convex polyominoes. Many of these classes are intimately related to certain classical families of discrete models in statistical mechanics. For example, the class of convex polyominoes with a diagonal symmetry is related to that of directed and convex polyominoes (or animals) with a compact diagonal source.

Analysis of population genetic models
Sabin Lessard

Sabin Lessard's research interests include a wide variety of population genetic models and the concomitant evolutionary dynamics. His ultimate goals are: a) to explain the maintenance of variability in biological populations, b) to develop mathematical and statistical techniques to analyse population genetic structures, c) to deduce general evolutionary principles, and d) to study populations with complex interactions between individuals.

q-special functions / The Efimov effect
Jean LeTourneux

Most special functions of mathematical physics admit q-analogs, namely deformations involving a parameter q. Just as Lie algebras provide a unifying framework for discussing special functions, q-deformations of these algebras provide a unifying framework for discussing q-special functions. In collaboration with Luc Vinet (CRM) and Roberto Floreanini (Trieste), Jean LeTourneux carries out a systematic investigation of the quantum algebraic interpretation of the q-special polynomials encompassed in the scheme of Askey-Wilson polynomials.

According to the Efimov effect, a three-body system has an infinite number of bound states when it involves two-body interactions that marginally bind the two-body system. Formal proofs of this effect are too complex to provide any physical intuition. Simpler proofs, given for special cases within the framework of the Born-Oppenheimer approximation, break down as soon as one goes beyond the lowest order approximation. With Bertrand Giraud (Saclay) and Yukap Hahn (Univ. of Connecticut), Jean LeTourneux investigates a certain number of questions raised by this situation.

Multi-scale modelling and statistics
Jean-Marc Lina, Brenda MacGibbon and Paul Turcotte

In the course of 1997, this group's research on wavelets was oriented towards statistical analysis and the modelling of stochastic processes. With image processing as its main application, this research follows on the lines of work done two years ago on orthogonal bases of dyadic complex wavelets, also known as Daubechies wavelets. The mathematical properties of these bases were the subject of intense study by the PHYSNUM group at the CRM; in particular, M. Ben Slimane, a postdoctoral fellow studied the question of the regularity of this type of wavelet. This allowed a better interpretation of the roles of amplitude and phase in complex wavelets. One of the theory's main achievements rests on the wavelets being an unconditional basis for Besov spaces. The norms associated to these spaces can be expressed in a simple fashion in terms of the amplitudes of the coefficients in a wavelet basis, and this property underlies the famous work of Lucier, de Vore, Donoho and Johnstone on robust estimators for signals with a background noise. We have used their analysis in the context of complex wavelets, putting the emphasis on the information contained in the phase of the coefficients. With a Bayesian formalism, this allowed a computation of maximum likelihood estimators for the amplitude of modes in complex wavelets, parametrised by the phases of the coefficients. This work was then applied to problems in image processing, and allowed the research program in this area to become more tightly focused, around questions in medical imaging and in satellite imaging. In the former, our collaboration with radiologists at the Notre Dame hospital now concentrates on the statistical analysis of stereotactic images of biopsies. In the second case, our expertise in the statistics of complex signals led to the study of satellite interferometry images. These projects were the source of two summer studentships in 1997 (P. Scott, of McMaster University, and S. Demers, from Laval University) The computer analysis was taken in hand by P. Turcotte, using his J. Wave package, dedicated to the multi-scale analysis of complex images.

Nonseparable wavelets in 2-d
Michel Mayrand

Michel Mayrand works on the Command and Control System (CCS) for the Canadian Patrol Frigates (CPF). The approach used by the Research team of which he is a member consists in decomposing the different subsystems of the CCS, namely Multi-Sensor Data Fusion, Situation and Threat Assessment, and Resource Management, into a set of agents which perform small specific tasks and interact in a common fashion via a controller and a Blackboard architecture. The Blackboard itself is a global database which is available to all Knowledge Sources (the agents) in the system, and which contains all the active problem-specific data objects needed by, or produced by, the agents, and which are part of the solution space to the problem. Compared with traditional programming, the natural modularity of this solution makes it easier to maintain and to parallelise using multithreading. Special efforts have been made to improve the speed of this expert system for manipulating large amounts of abstract data and for solving large and complex problems. This is achieved by implementing data-driven algorithms such as the Rete Algorithm for activating rules efficiently. This expert system is also designed to support forward and backward chaining for problem solving.

Computational Galois theory and moonshine
John McKay

The research of John McKay for the year continued to focus on two questions: computational Galois theory and moonshine.

Computational Galois groups is a topic of research which has progressed to the stage that we have named descriptions of all the transitive permutation groups of degree up to 15. A coauthor has extended the list of groups to degree 31. Although computing monodromy groups of polynomials is relatively easy as it is defined in terms of homotopy, computing Galois groups over Q is far harder — and is ultimately limited by the size of polynomials/Q that can be factored. Good upper bounds for the Galois group (or easily computed properties that bound it) are much needed.

The name "moonshine" refers to a series of questions surrounding modular functions and the representations of finite groups, in particular the Monster. Norton defined a class of functions known as replicable functions which generalizes the class of Hauptmodules, which in turn generalizes the elliptic modular function, j(z). By generalizing Dedekind's construction of j(z), and working with differential equations, we are able to determine many useful invariants of Hauptmodules. These invariants, of a geometric and number theoretic nature, are of much interest. An equivalent formulation leads to a dynamical system for each Hauptmodule. These dynamical systems are each associated to a non-associative commutative algebra. A possible explanation of moonshine is the existence of a 24-dimension manifold such that the Monster group can act on its loop space — but such has not been found yet.

Non-crystallographic root systems
Jiří Patera

There are several linked aspects to this research program, with the first being the dominant one:

1. Aperiodic long range order in physics. This is a study of properties of quasicrystals and aperiodic lattices as alternatives to lattices in physics. It includes a preparation of a review for the Physics Reports with tentative title: "Algebraic approach to the theory of quasicrystals."

- A comprehensive overview of as large a number of ordered aperiodic structures as possible for quasicrystals and aperiodic lattices, which became feasible only within our new approach.
- Use of new basic operations on quasiperiodic structures, colouring, quasiadditions, and inflations, to study sub-quasicrystals of quasicrystals, and the minimal number of seed points from which these operations generate the rest of the quasicrystal.
- Study of algorithmic processes which could be interpreted as local growth rules.
- The study of Fourier transforms of the quasicrystals in order to make a comparison with diffraction patterns found in experiments.
- Determination of properties of point sets observed in the experiments, using our new exhaustive description of inflation symmetries and minimal distances in quasicrystals.
- Calculating the percolation thresholds for aperiodic lattices, the static exponents and fractal dimensionality of the percolation clusters.

2. Determination of the sets of additive quantum numbers for a given symmetry group. The main intended step is a classification of the finest gradings of the real classical Lie algebras, starting from our results on complex algebras.

3. Graded contractions of representations of Lie groups. This is a continuation of a study of deformations of representations of the most important Lie algebras in physics.

4. Image analysis and pattern recognition. This is an industrial collaboration with Lockheed Martin Canada Inc. involving three graduate students and a postdoctoral fellow.

5. Computing methods in group theory and software development. Computer graphic implementations of our algorithms is indispensable for our other projects. Much of our intuition about quasicrystals is derived from seeing their images.

Lie theory and combinatorics
Christophe Reutenauer

A work with Paul Cohn, which gives a construction of the free field, an algorithm for its word problem and a primary decomposition of noncommutative fractions, is in course of publication. The same is true for an article with Christian Kassel, in algebraic K-theory, where the authors give a Coxeter-like presentation for the semi-direct product of the symmetric group and the Steinberg group (type A), together with investigations of the analogue in their case of the K2. With the same coauthor and Alain Lascoux, Christophe Reutenauer is presently working on a parametrisation of Schubert cells, resting on the special matrices used in the previous work.

Clones and their applications
Ivo Rosenberg

1. **Universal algebras:** The main topic is the study of clones on a finite universe A, which are composition closed sets of operations on A, a basic problem for finite algebras. Ideals, congruence kernels and discriminator algebras were also studied. Algebraic duality, an extension of Stone's duality for Boolean algebras, allows topological representations of algebras. It was shown that dualisability is invariant under nilpotent shifts.
2. **Hyperalgebras:** A hyperalgebra on A is an algebraic structure with values in the set P of nonvoid subsets of A. I. Rosenberg studied them as c-isotone algebras on P, which allowed a universal algebra approach to hyperalgebras and lead to interesting problems on c-isotone clones on P. In particular, hypergroups on A can be studied as c-isotone monoids on P.
3. **Switching functions and decision trees:** I. Rosenberg studied counting problems for certain Boolean functions and decision trees.

Qualitative study and bifurcations in differential equations
Christiane Rousseau

One of the long-term goals of Christiane Rousseau's research program is the completion of the proof for the existence part of Hilbert's 16th problem for quadratic systems, i.e. to show that there exists a uniform bound for the number of limit cycles in a quadratic system. This project, initiated in 1991 with F. Dumortier and R. Roussarie, is progressing steadily. An important step made recently by Rousseau and H. Zoladek by exploiting simultaneously Khovanskii and Bautin's techniques for the centres and Roussarie's techniques for blowing up of families, allows one to hope for a complete solution in the coming three to ten years.

All the techniques introduced here have an intrinsic interest going far beyond their application to the above problem. With Roussarie, Rousseau has applied some of them to the study of certain homoclinic loops in 3-dimensional space, and their Ph.D. student, L. S. Guimond, is making further progress in that direction.

Another aspect of Rousseau's research project will be devoted to algebra-geometric methods applied to the study of polynomial vector fields. She is working on the problem of the centre (in collaboration with D. Schlomiuk) and on the geometric characterization of isochrone vector fields (with P. Mardešić and L. Moser-Jauslin).

This study of polynomial vector fields has a direct impact on still another aspect: the study of singularities of vector fields of higher codimension (typically larger than or equal to 3). The bifurcations of these singularities are organizing centres of bifurcation diagrams occurring in many applied models.

Time Series Modelling
Roch Roy

Roch Roy's research deals with the modelling of time series. Although the analysis and modelling of time series is a classical field in statistics, its remains of current interest since it is applied in many scientific disciplines. His recent research work was concentrated on the following projects:

a) development of a new method for identifying multivariate ARMA models;
b) estimation of characteristics of the distribution of a vector of serial correlations, among which the estimation of the covariance structure by a classical method based on asymptotic results and by resampling methods;
c) development of tests for checking the independence of two multivariate time series that are stationary or not;
d) study of the properties of a class of models of the type "generalized linear regression" in order to describe integer-valued time series.

Biomathematics and sociolinguistics
David Sankoff

In biomathematics, David Sankoff works on algorithms for the analysis of DNA sequences and he has, within the context of the human genome project, extended this discipline to the development of methods for studying genome evolution resulting from the process of chromosomal rearrangement. This has resulted in the development of algorithms (in collaboration with John Kececioglu and Gopalakrishnan Sundaram) for sorting permutations using a small set of operations: reversals, transpositions, translocations. Sankoff and Vincent Ferretti study syntenic sets of genes in collaboration with Joseph Nadeau, a geneticist at Case Western Reserve, and several mathematics and statistics students. In phylogeny, Sankoff and Ferretti have developed a method of nonlinear phylogenetic invariants.

In sociolinguistics, David Sankoff directs a program whose goal is a rigorous statistical methodology for the analysis of syntactic variation and phonology in spoken language, based on computerized transcriptions of corpora of free speech. With David Rand, he developed and distributed a software package (GoldVarb) for linguistic data analysis. His empirical interests include bilingual syntax, specifically methods for distinguishing alternating borrowing codes, and the study of particles of speech.

Local and Global Studies of Analytic Vector Fields
Dana Schlomiuk

Dana Schlomiuk works on local and global problems on families of planar analytic vector fields. In this project, interdisciplinary methods intervene (algebro-geometric or of commutative algebra, bifurcation theory, holomorphic foliations, etc.).

The project concerns the global analysis of families of quadratic vector fields (with J. Pal, Y. Dupuis, J. Surpenant) and the problem of the centre (with L. Farell). Results were obtained on the understanding of the dynamics and global geometry of the classes of systems which were studied.

Presently, work continues on the study of ideals intervening in the problem of the centre, on the algebraic invariant curves of polynomial systems, in particular on the multiplicity of such curves and on its role in the integrability of the systems.

Multi-sensor data fusion
Elisa Shahbazian

Elisa Shahbazian is the director of research and development at Lockheed Martin Canada. In particular she is coordinating a team of ten researchers working in the areas of data fusion and image processing. Current research projects include: image processing and pattern recognition, with the collaboration of Prof. Jiří Patera and three students; real-time analysis of data for the Canadian Patrol Frigate (CPF); validation of data fusion for aerial reconnaissance; data fusion and image processing for aerial reconnaissance; a feasibility study for the CP-140 patrol aircraft; pursuit and targeting using MSDF.

Nonsmooth analysis: theory and applications
Ronald Stern

The field of nonsmooth analysis, pioneered by F. H. Clarke in the 1970's, provides a "calculus" for functions which are nondifferentiable and possibly not even continuous, and which are therefore not amenable to treatment by standard (i.e. smooth) methods. On the geometric side, there have been many important applications of this theory in recent years, notably in optimization, control, and general dynamical systems (invariance theory and existence of equilibria). Ron Stern, in collaboration with F. H. Clarke, Yu. S. Ledyaev, P. R. Wolenski, and J. J. Ye, has been contributing in these areas in recent years. At present, a general problem Stern is working on is the construction of control feedback laws in certain control problems, using the tools of nonsmooth analysis.

Additive Sequences of Permutations
Jean M. Turgeon

The combinatorial problem of optimally arranging a set of large antennae used in radio astronomy has led to the notions of perfect systems of difference sets and of additive sequences of permutations. The question of existence for the systems can be considered as solved by Kotzig and Laufer, but enumeration and construction remain to be studied. For this construction, the additive sequences are a precious tool, but they themselves pose difficult problems of existence and enumeration. For sequence bases with no repetitions, the list of all sequences of length 2 has been compiled by Abraham, Kotzig and Turgeon up to cardinality eight. Among the bases of cardinality eight, Abraham and Turgeon discovered an equivalence relation by means of linear transformations. The sequences of length 2 with repetitive bases are now known up to cardinality six. Much progress has also been accomplished concerning sequences of length greater than 2.

Data fusion
Pierre Valin

Pierre Valin directs research on data fusion at Lockheed Martin Canada for the maritime surveillance aircraft CP-140. Part of this work is in collaboration with Professors D. Grenier and M. Lecours of the Department of Electrical Engineering and Computer Science at Université Laval. He is also scientific advisor for the production of a synthetic aperture radar for the same plane, for which Lockheed Martin Canada is the main contractor. In physics, his research now centres on hadronic multiplicities.

Quantum physics and combinatorics
Luc Vinet

The main objectives of Luc Vinet's research projects are:

(i) to develop the appropriate theoretical tools for solving important models of quantum many-body physics;

(ii) to advance the theory of symmetric functions.

Last year, in collaboration with his Ph.D. student Luc Lapointe, Luc Vinet made a major step towards obtaining an algebraic solution of the Calogero-Sutherland model, and in so doing proved long-standing conjectures on some of the most important symmetric polynomials in algebraic combinatorics. With Roberto Floreanini (Trieste) and Jean LeTourneux, Luc Vinet has pursued his systematic investigation of the quantum algebraic interpretation of q-special functions. He has also undertaken a study of difference equations from the symmetry point of view.

Lie symmetries of difference equations
Pavel Winternitz

Lie groups as symmetry groups of differential equations provide powerful tools for solving such equations, especially when combined with singularity theory and other attributes of modern integrability theory. Pavel Winternitz, together with Decio Levi (University of Rome III) and Luc Vinet, is developing a formalism that should be equally useful for treating difference equations. Two different approaches are being considered simultaneously. One applies to differential difference equations, involving both continuous and discrete variables. Transformations involving the continuous variables are treated via Lie algebras, the discrete ones are treated globally. In the second approach all variables are continuous, but their increments are discrete, i.e. differences figure instead of derivatives. The symmetry group is then constructed via "discrete prolongation" techniques, adapted from the usual Lie techniques used for differential equations. In order to recover all Lie point symmetries of a differential equation in the continuous limit, it turns out to be necessary to consider a much larger class of symmetries in the discrete case. They act simultaneously on the entire lattice, not just at one point.

On the estimation of a regression function
Yannis G. Yatracos

Necessary and sufficient conditions will be provided for the existence of consistent estimates in nonparametric regression when the independent variable is a random vector. The approach will be based on the fact that estimation of a regression function may be seen as estimation of several parameters. The conditions obtained in this case by Kakutani and Shepp will be used to derive the results also for the case of a regression type function.

Shape Optimisation
Jean-Paul Zolésio

The research of Jean-Paul Zolésio centres on questions of modelling in continuum mechanics, more particularly on problems involving free surfaces and free boundaries. The particular techniques developed in this research program are ones which deal with shape optimisation, and involve questions of both a theoretical and practical nature. Problems considered include:

A) the identification of unknown boundaries; inverse problems in geophysics, acoustics and thermo-elasticity,
B) dynamical free boundaries,
C) control of dynamical free boundaries,
D) stabilisation of elastic structures by periodic variation of the boundary,
E) boundary control for non-cylindrical evolution problems,
F) existence results for problems of shape optimisation,
G) nonsmooth analysis for variation of domain,
H) the intrinsic theory of shells and intrinsic geometry of surfaces,
I) a theory of fluid shells and an approach to the problem of limit layers in viscous flow.

Parts F, G and H of this program are the result of collaboration with M. Delfour.

COLLABORATIONS

The CRM is strongly committed to its national mission. In this direction, it takes measures to ensure that the largest possible number of scientists across Canada benefit from its activities and become involved in their planning. For instance, it appoints to its Advisory Committee eminent Canadian scientists from various parts of the country; it is present at all important forums where the future directions of the Canadian mathematical sciences are discussed; it urges its organizers to make efforts to ensure the participation of the Canadian specialists in their activities; it seeks Canadian graduate students and postdocs to take part in its programs; it has made the hiring of Canadian postdocs from outside Quebec a priority; it organizes and supports scientific events across the country; and it collaborates with Canadian institutes, societies and associations.

The CRM also plays a major national role through the leadership it exerts in the selection of its scientific programs, the infrastructure it offers, the interactions it has developed with various disciplines as well as with the business and the industry sectors. Finally, it collaborates with the Montréal Universities in organising scientific activities in the Montréal area such as the CRM-ISM colloquium, and through its partnership agreements.

The CRM operates in the two official languages of Canada and is highly visible on the international scene. In keeping with its national role, it is coordinating its activities with the Fields Institute, PIms, CMS, CAMS, SSC, CAP, AARMS, CCARMS, and collaborating with technology transfer centres as well as with other institutes abroad. These aspects of the CRM's national role are described below.

Fields Institute

The importance of coordinating the scientific activities of the CRM and the Fields Institute (FI) was stressed when the FI was created. Since the beginning communication between the two centres has been excellent. Thus, the directors have always been in regular contact; also, the CRM has appointed to its Advisory Committee (AC) R. Moody who was then on the FI's Scientific Advisory Panel (SAP); D. Dawson has been on this CRM AC for the last four years and has remained a member during his first year as director of FI. Thus he is very well informed of the CRM plans; similarly, the FI nominated F. Lalonde who is on our AC to its SAP. In 1994, at the request of NSERC, the CRM-FI coordinating committee was formed to monitor and facilitate the coordination between the two institutes.

As a result there has been little repetition in the scientific programs of the two institutes and more importantly, beyond the coordination, much collaboration has developed. In this vein let us mention the following.

The CRM-FI prize awarded in recognition of outstanding accomplishments in the mathematical sciences in Canada was created in 1994. This year's winner is James Arthur of the University of Toronto. The administrative responsibility in this matter alternates each year between the CRM and the FI. Nominations for the 1997 prize are currently being received.

The CRM and the FI have jointly sponsored many scientific events. J. Patera from the CRM co-organized a yearlong theme program at the FI. The CRM is publishing the proceedings of a workshop held at the FI and vice versa. Some postdocs have shared their time between the CRM and the FI and there have been many exchanges and visits between the scientific personnel of the two institutes.

The CRM and the FI were both involved in the development of the National Network for Collaboration in the Mathematical Sciences (NNCMS). Moreover, in 1995, the CRM took the initiative of bringing together the FI and PIms in an effort to develop a national network for computing in the mathematical sciences. A proposal was presented to NSERC in the framework of its Major Facility Access Program. Although the project was not funded, $ 75K was given as seed money.

It is certainly the intent of the CRM and the FI to continue their collaboration in the future. In 1997, the CRM and the FI co-sponsored 9 scientific meetings, and collaboration in this area should remain this high in the years to come. A good example is the 1998 Conference on Formal Power Series and Algebraic Combinatorics which will take place at the FI and to which the CRM has already committed funds. In line with a recommendation of the CRM-FI coordinating committee, this meeting will have the additional merit of extending to 1998 and outside Montréal, the 1996-1997 theme year in combinatorics of the CRM. In 1998 CRM regular member D. Sankoff will organize one of the events to be held at FI in their theme year on probability.

Pacific Institute for the Mathematical Sciences

The CRM has a long tradition of collaboration with the western universities that are now part of the PIms consortium and with many of the scientists that are much involved in the management of this institute. We want and will do all we can to maintain and expand such collaborations through the new PIms.

In recent years the CRM has given substantial support to activities organized by people and universities that are today part of PIms. In some cases, these were important elements of CRM thematic programs. To name a few: the summer school of 1993 on mathematical biology organized at UBC by R. Miura — this school actually launched the 1993 CRM theme program on dynamical systems; the summer institute in mathematical physics also organized at UBC in the following year by J. Feldman and L. Rosen; the workshop on organic mathematics organized by J. Borwein through the Centre for Experimental and Constructive Mathematics (CECM at SFU) and connected to the 1995 CMS winter meeting at Simon Fraser University; the first CRM summer school in Banff had G. Semenoff, the 1996-97 director of the UBC site of PIms, as its main organizer, etc.

Among activities to come that are largely supported by the CRM and organized by PIms members, we should like to mention the 1st Vancouver Meeting in Probability which is being organized by M. Barlow and E. Perkins from UBC and which will take place this summer as well as the 1998 Summer School in Banff on Algebraic Cycles organized under the chairmanship of J. Lewis from the University of Alberta and an important part of the CRM 1998-1999 program in Number Theory and Algebraic Geometry.

It is the CRM's wish to maintain and expand collaboration of that sort with PIms and to encourage and support activities organized by PIms that would prolong and complement the theme programs of the CRM. We also envisage exchanges of postdocs between PIms and CRM (S. Kallel who is currently a postdoc at CRM will move to PIms next year) and a joint internship program in business and industry for undergraduates. This last project could be a step towards connecting our respective networks for research in industrial mathematics.

Canadian Associations and Professional Societies

With the development of the NNCMS project, two regional university associations have been created: the Atlantic Association for Research in the Mathematical Sciences (AARMS) and the Central Canada Association for Research in the Mathematical Sciences (CCARMS). The CRM is already involved with these organizations and looks forward to developing closer ties. Of the 1997 CRM-sponsored activities, three will be held at universities that are part of AARMS (Memorial [1] and Dalhousie [2]) and one at an institute that is part of CCARMS, namely the IIMS of the University of Manitoba.

The CRM is also much involved with a number of professional societies (CMS, CAMS, CAP, SSC) related to the mathematical sciences. Over the years and particularly recently, the CRM has funded many meetings that were held under their ægis.

An important segment of the Canadian mathematical community gathers at the winter and summer meetings of the Canadian Mathematical Society (CMS). This year the CRM subsidized the session on Complex Analysis and Geometry at the winter meeting (Western Ontario, December 1996). It is supporting the International Linear Algebra Society Symposium on "Fast Algorithms for Control, Signal and Image Processing" connected to the session on Linear Algebra of the CMS Summer Meeting in June 1997 (Winnipeg). The president of the CMS is an ex-officio member of the CRM Advisory Committee and is thus able to make the case directly for activities that the CMS would wish the CRM to support.

The CRM and the Canadian Association of Physicists (CAP) have jointly created the CAP-CRM Prize recognizing outstanding work in theoretical and mathematical physics. (CRM is responsible for seeking nominations and managing the international committee that chooses the yearly winner.) The CRM is subsidizing this summer (1997) the CRM-Fields-CAP Summer Workshop in Theoretical Physics to be held at Queen's University. The Kingston Summer Workshops have been organized and held at Queen's for many years. However, with the cancellation of the NSERC non-core programs, support for this event had disappeared. With this summer workshop, the CRM joins the effort to revive this tradition.

Each year the Canadian Applied Mathematics Society (CAMS) holds a general meeting which takes place this summer at the Fields Institute. The CRM is supporting this conference. J. Bélair from the CRM is vice-president of the Society.

The 1997-1998 theme year in statistics has given the CRM the opportunity to collaborate with the Statistical Society of Canada (SSC). In particular, the CRM will be supporting the SSC annual congress of 1998 (and possibly of subsequent years). The CRM has also proposed to the SSC the creation of a prize to recognize important work by Canadians in Statistics.

Foreign Institutes and Organizations

The Université de Montréal is part of the 3x3 Canada-China Consortium with UBC, Toronto and McGill in Canada; Beijing, Nankai and Tsing Hua Universities in China. The CRM took the lead in writing the mathematics component of the multi-million proposal presented last Summer to CIDA by the four Canadian universities. (The final answer from CIDA has not yet been released but it is believed that, unfortunately, it will be negative.) To further develop these collaborations a protocol of exchange between the CRM and the Institute of Mathematical Sciences at Nankai University has been signed. A first week-long joint meeting was held in Tianjin in August 96. Efforts are being made to find funding to carry on and develop these exchanges.

The CRM and the Mathematical Sciences Research Institute (MSRI) in Berkeley had part of their 96-97 theme year devoted to combinatorics. Coordination between the two institutes prevented conflicts and flavoured complementarity in the programs. Several scientists attended events at both institutes.

This fall, the CRM will host a regional meeting of the American Mathematical Society (AMS). In addition to the plenary talks there will be 12 parallel sessions, and more than 200 participants are expected.

INDUSTRIAL PARTNERSHIPS

In 1996-97, the Centre de recherches mathématiques continued its efforts to further develop the solid network of industrial partnerships that it has put in place over the last few years. It has, for example, provided a home base, with technical support, for several research groups involved with contractual work; it has named four private sector researchers as associate or visiting members; it has also expanded further its program of industrial post-doctoral fellowships. The year's key accomplishment, however, is of course the establishment of the Network for Computation and Mathematical Modelling (**ncm_2**).

THE NEW NETWORK FOR COMPUTATION AND MATHEMATICAL MODELLING (NCM_2): A BOON FOR STRATEGIC NATIONAL DEVELOPMENT

During the year 1996-97, the CRM took the lead in the development of a consortium of five Montréal-based research centres (CRM, CERCA, CIRANO, CRT and GERAD[1]) in putting together an application to NSERC's new Research Networks Program. The proposal was based on a networking of complementary mathematical and computational tools. More than 35 university researchers associated with the five centres signed the proposal, along with 16 industires, banks, government agencies and ministries. These contributed more than $ 800K in cash and $ 800K in kind for the first year of operation. NSERC awarded the **ncm_2** a grant of $ 3M, spread over five years.

The programs funded are in three main areas: risk management, information processing, and transport and telecommunications. In risk management, the emphasis is on questions linked to financial risk, risk in insurance, as well as technological and environmental risk. This part of the project will integrate the expertise of the centres involved into a global vision of the aspects of risk management, both at the conceptual and the methodological levels.

The information processing portion of the Network includes projects in medical imaging, teledetection, real-time decision procedures and parallel computation. The aim is to exploit the various methods available for managing large masses of data so as to make rapid and informed decisions.

In the transport and telecommunications axis, there are projects dealing with intelligent transportation systems, with rail and air transport, with the optimisation of multimode transportation networks, with the planning and management of transporters, with the localisation, the scheduling and the routing of vehicles, and with the planning of telecommunication networks.

The forty-odd university researchers attached to the network work in different areas, but often use similar methods. For example, the models and methods for collecting, collating, and managing large masses of data are used in teledetection, in aerial surveillance, in intelligent transportation systems and in real-time allocation of resources. Another example is afforded by neural networks, used in areas as diverse as medical imaging and the evaluation of risk in financial markets. One technique that reappears in almost all the areas of the program is that of parallel computation, whether it is in the modelling of flood forecasting in the Saguenay, in the elaboration of work schedules in international air transport, or in the design and operation of transportation and telecommunications networks. The **ncm_2**, by assembling all of these disciplines, offers a one-stop approach to industries interested in its knowledge and resources.

The **ncm_2** also possesses a diversified computer network, which must and will be continually renewed. This includes a large number of work-stations, as well as a network of medium- and high-performance networked systems for large-scale computation.

The business and public sector partners of the Network are: Ad-Opt, Atlantic Nuclear Services, the National Bank of Canada, Bell Mobility, the Caise de Dépôt et Placement du Québec, Canadian Pacific, the Chaire de gestion des risques of the École des Hautes Études Commerciales, the Chaire Jarislowsky en technologie et communication internationale of the

École Polytechnique, the Ministry of National Defense, GIRO Enterprises, Environment Canada, the Groupe Cartier, INRO Consultants, Hydro-Québec, Silicon Graphics, the Société d'Assurance Automobile du Québec, Lockheed Martin Electronic Systems of Canada, and Urgences Santé.

One of the main objectives of the Network is the training of highly qualified personnel, and more than 95% of NSERC's grant is to go into hiring Master's and Ph.D. students, as well as post-doctoral fellows. The integration of the various groups within the network, and the dissemination of their output is to be facilitated through workshops, seminars, and intensive mini-courses.

By taking the lead in organising the Network, the CRM has greatly consolidated its industrial base. The Network's partnerships provide a very important access to industrial opportunities for the CRM, and so for the mathematical community. In the words of the site visit committee which approved the proposal:

"With its impressive participant base, it can arguably become the outstanding industrial-university mathematical research program in the hemisphere."

The Network is to be inaugurated in the fall of 1997.

Industrial Postdoctoral Fellowships Program

The CRM started up this program four years ago to contribute to research in industrially oriented mathematics, and to encourage collaboration between universities and industry. Four fellowships, funded jointly by the CRM and by industry, were awarded in 1996-97. The CRM's industrial partners, in this program, include: Ad Opt and Cognologic, which offered a postdoctoral fellowship (p.d.f.) for a recent Ph.D. to work on the problem of optimising monthly work schedules for airline employees, Environment Canada, which offered a p.d.f. in modelling the regional atmosphere; Bombardier Canada, Pratt & Whitney and Environment Canada, a p.d.f. to study wing icing problems, and Bombardier Canada, GE Canada, Hydro-Quebec and Environment Canada a p.d.f. in the area of large scale turbulence. Another important element of the CRM's p.d.f. program is provided by its PHYS-NUM group, headed by Bernard Goulard. They have important links to Atlantic Nuclear Services and to Lockheed Martin, and specialise in the application of techniques such as neural networks and wavelets to questions such as reactor control and image processing. Several of their postdoctoral fellows now have full-time research jobs in industry.

This fellowship program will expand significantly, within the **nc***m*$_2$.

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[1] CERCA is the *Centre de recherche en calcul appliqué*;
CIRANO is the *Centre interuniversitaire de recherche en analyse des organisations*;
CRT is the *Centre de recherche sur les transports*;
GERAD is the *Groupe d'études et de recherche en analyse des décisions*.
Each is supported by more than one university.

AWARDS, DISTINCTIONS & LANDMARKS

Michel Delfour and Francois Lalonde elected to the Royal Society of Canada

Michel Delfour, a long-time member of the CRM, was again a recipient of a notable national distinction, being elected to the Academy of Sciences of the Royal Society of Canada this year, after being awarded the Prix Urgel Archambault by ACFAS last year.

After completing the Honours Degree in Electrical Engineering and winning among other distinctions the Ernest Brown Gold Medal for highest ability throughout the undergraduate course at McGill University, Michel Delfour joined the Systems Research Center of the Case Institute of Technology where he obtained his Ph.D. in Mathematics in the joint program in Mathematical Systems Theory and Control. Attracted by the newly created CRM at the Université de Montréal, he first came as a visiting research scientist in 1970 and became Professor in the Department of Mathematics in 1983.

His research activities cover a wide range of topics in Engineering, Modeling, Computing and Mathematics. His current areas of interest include the control and design of shapes and structures. Much of his work in these areas was developed in the course of an extensive collaboration to the Canadian Space Program, with numerous applications in the design of satellites of communication. His most recent contributions are in the area of thin shells made of composite or smart materials with applications to the control of structural vibrations and the shape optimal design of all-purpose electrical vehicles. His research also covers the areas of modelling and control by delay equations and numerical methods in impulsive differential equations.

He has had a long term association with Industry Canada for the evaluation and planning of land mobile communication systems in large Canadian urban areas where there is a strong and growing demand for new services and spectrum resources. Over the years he has maintained consulting activities with a number of organizations such as Hydro-Québec, Spar Aerospace, Novacorp Consulting and the Department of National Defense.

In the course of his career, Michel Delfour has received several important awards and distinctions: as well as the Prix Urgel Archambault, he was awarded a Killam fellowship in 1989-1991. He has an extensive record of service to the mathematical community, both with federal and provincial granting agencies and with the Canadian Mathematical Society, of which he was the President from 1992 to 1994. During his years at the CRM, his students and post- doctoral fellows have found positions in the university system and more recently in the industrial sector.

Francois Lalonde was also elected this year to the Royal Society of Canada. Professor Lalonde completed a Bachelor's degree in Physics in 1976 at the Université de Montréal, which was followed by a Master's degree in Complexity Theory and a Ph.D. in Mathematics, also at the Université de Montréal. He then went on to do further work at the Université de Paris-Orsay, which awarded him a Doctorat d'État in 1985. Returning to Montréal, he took up an NSERC University Research Fellowship at UQAM, and became a member of the CRM's Bureau de Direction in 1988. He has served on its Advisory Committee since 1995.

Professor Lalonde's work centres on the rapidly emerging area of symplectic topology, whose main focus is the classification and structure of symplectic manifolds. This classification is rendered difficult by the fact that there are no local invariants for symplectic structures analogous to curvature, and the approaches to this classification have only been developed in recent years. Prof. Lalonde combines in his work a remarkable mastery of techniques of isotopy from differential topology, the analysis of elliptic pde through the use of pseudo-holomorphic curves and the Seiberg-Witten equations, as well as physical intuition. He has several important breakthroughs to his credit, in particular some of the first results applicable to all symplectic manifolds: an extensive study of the energy functional, symplectic capacity, and the geometry of the space of Hamiltonian diffeomorphisms, as well as a classification of ruled symplectic surfaces.

He is also heavily involved at the moment in the mathematical community, as director of the Institut des Sciences Mathématiques (ISM), as overall chair of NSERC's mathematics Grant Selection Committees, and as a member of the scientific advisory panels of both the CRM and the Fields Institute.

David Sankoff Doubly Honoured

David Sankoff, a regular member of the CRM since 1969, was doubly honoured this past year. He was named a Fellow of the Royal Society of Canada and was renewed as a Fellow of the Canadian Insti-

tute for Advanced Research, through the year 2002.

Dr. Sankoff received his B.Sc., M.Sc. and Ph.D. from McGill University, writing his thesis under the direction of Professor Donald Dawson. He has been at the CRM since then and currently holds the position of "chercheur titulaire" as well as that of professeur in the *Département de mathématiques et de statistique* of the Université de Montréal.

Dr. Sankoff has made major contributions to the fields of linguistics and computational biology. In particular he has done pioneering work in the areas of sequence comparison, genome classification, and problems of efficiency and complexity related to phylogenic analysis. In linguistics he has dealt with problems of linguistic variation, discourse analysis, and lexicortatic theory. He has been a principal researcher in a major study of the spoken French of Montréal.

He is the editor of the journal *Language, Variation and Change* published by Cambridge University Press and is on the editorial boards of four other important journals in the fields of biology and linguistics.

In addition to the honors mentioned previously Dr. Sankoff received the Prix Vincent of the *Association canadienne-française pour l'avancement des sciences* in 1977. He has also been rewarded with invitations to address important meetings, various visiting positions, and membership on grant-selection committees in Canada, France, and the United States.

A Sixtieth Birthday Symposium for Jiří Patera and Pavel Winternitz

A Symposium was held this past year to celebrate the sixtieth birthdays of two of the CRM's outstanding resident researchers, Jiří Patera and Pavel Wintenitz. Both Jiří and Pavel have been at the CRM for a long time; Jiří since its inception, and Pavel since 1972, moving here mostly at Jiří's behest. Together, they helped establish the CRM as a leader in Mathematical Physics, collaborating on a number of topics such as the theory and applications of two variable expansions of scattering amplitudes, the connections between symmetries of partial differential equations and separation of variables, and the classification with Hans Zassenhaus of the subgroups of physically important groups and of the maximal Abelian subalgebras of complex and real simple Lie algebras. Their work has diverged somewhat in recent years, with Pavel concentrating his efforts on Lie symmetries of differential equations and difference equations, and links to the Painlevé property and integrability, while Jiří works on problems in Lie theory such as elements of finite order in groups, the relationship between grading and contractions, cells of root lattices, quasicrystals and aperiodic order. The two have had an enormous number of students and collaborators over the years, many of whom were at the symposium and contributed to its resounding scientific success.

PUBLICATIONS

The CRM publishes monographs, lecture notes, proceedings, software, videos and research reports (for the latter see below). It has several collections. The in-house collection Les Publications CRM offers many titles in both English and French. The CRM also has publishing agreements with the American Mathematical Society (AMS), Springer-Verlag and International Press. Two collections, edited by CRM, are published and distributed by the AMS. They are the CRM Monographs and the CRM Proceedings and Lecture Notes. Springer-Verlag publishes the CRM Series in Mathematical Physics and the CRM Subseries of the Springer Lecture Notes in Statistics. The following list "Recent Titles" contains books that have appeared during the year 1996-1997 or that will be published soon.

Recent Titles

AMS: *CRM Proceedings & Lecture Notes*

- Luc Vinet (ed.), *Advances in Mathematical Sciences: CRM's 25 Years* (Montréal, 1994), CRM Proc. Lecture Notes, vol. 11, Amer. Math. Soc., Providence, RI, 1997.
- Peter G. Greiner, Victor Ivrii, Luis A. Seco and Catherine Sulem (eds.), *Partial Differential Equations and their Applications* (Toronto, 1995), CRM Proc. Lecture Notes, vol. 12, Amer. Math. Soc., Providence, RI, 1997.
- Michel Delfour (ed.), *Boundaries, Interfaces and Transitions* (Banff, 1995), CRM Proc. Lecture Notes, Amer. Math. Soc., Providence, RI, 1998 (to appear).
- Alain Vincent (ed.), *Numerical Methods in Fluid Mechanics* (Montréal, 1995), CRM Proc. Lecture Notes, vol. 13, Amer. Math. Soc., Providence, RI, 1998 (to appear).
- John Harnad and Alex Kasman (eds.), *The Bispectral Problem* (Montréal, 1997), CRM Proc. Lecture Notes, vol. 14, Amer. Math. Soc., Providence, RI, 1998 (to appear).
- François Lalonde (ed.), *Geometry, Topology and Dynamics*, (Montréal, 1995), CRM Proc. Lecture Notes, vol. 15, Amer. Math. Soc., Providence, RI, 1998 (to appear).
- Olga Karlampovich (ed.), *Summer School in Group Theory* (Banff, 1996), CRM Proc. Lecture Notes, Amer. Math. Soc., Providence, RI, 1998 (to appear).
- Michel Fortin (ed.), *Plates and Shells* (Québec, 1996), CRM Proc. Lecture Notes, Amer. Math. Soc., Providence, RI, 1998 (to appear).
- Serge Dubuc (ed.), *Spline Functions and Theory of Wavelets I, II*, CRM Proc. Lecture Notes, Amer. Math. Soc., Providence, RI, 1998 (to appear).

AMS: *CRM Monographs*

- Yves Meyer, *Wavelets, Vibrations and Scaling*, CRM Monograph Series, vol. 9, Amer. Math. Soc., Providence, RI, 1997.
- James D. Lewis, *A Survey of the Hodge Conjecture*, CRM Monograph Series, Amer. Math. Soc., Providence, RI, 1998 (to appear).

Springer-Verlag: *CRM Series in Mathematical Physics*

- Luc Vinet and Gordon Semenoff (eds.), *Particles and Fields* (Banff, 1994), CRM Series in Mathematical Physics, vol. 1, Springer, New York, 1998 (to appear).
- Luc Vinet and Jan Felipe van Diejen (eds.), *Calogero-Moser-Sutherland Models*, CRM Series in Mathematical Physics, Springer, New York, 1998 (to appear)
- Yvan Saint-Aubin and Luc Vinet (eds.), *Algebraic Methods in Physics—A Symposium for the 60th Birthday of Jiří Patera and Pavel Winternitz*, CRM Series in Mathematical Physics, Springer, New York, 1998 (to appear)

Les Publications CRM

- Xavier Fernique, *Fonctions aléatoires gaussiennes, vecteurs aléatoires gaussiens*, Les Publications CRM, Montréal, 1997.
- Faqir Khanna and Luc Vinet (eds.), *Field Theory, Integrable Systems and Symmetries*, Les Publications CRM, Montréal, 1997.
- Maximilian Ya. Antimirov, Andrei A. Kolyshkin and Rémi Vaillancourt, *Mathematical Models for Eddy Current Testing*, Les Publications CRM, Montréal, 1998 (to appear).

AMS/International Press

- Duong H. Phong, Luc Vinet and Shing-Tung Yau (eds.), *Mirror Manifolds and Geometry*, AMS/IP Studies in Advanced Mathematics, Amer. Math. Soc., Providence, RI, Internat. Press, Cambridge and CRM, Montréal, 1998 (to appear).

Previous Titles

AMS: *CRM Proceedings & Lecture Notes*

- Donald E. Knuth, *Stable Marriage and its Relation to Other Combinatorial Problems. An Introduction to the Mathematical Analysis of Algorithms*, CRM Proc. Lecture Notes, vol. 10, Amer. Math. Soc., Providence, RI, 1996.
- Joel S. Feldman, Richard Froese, and Lon M. Rosen (eds.), *Mathematical Quantum Theory II: Schrödinger Operator* (Vancouver, 1993), CRM Proc. Lecture Notes, vol. 8, Amer. Math. Soc., Providence, RI, 1995.
- Decio Levi, Luc Vinet, and Pavel Winternitz (eds.), *Symmetries and Integrability of Difference Equations* (Estérel, 1994), CRM Proc. Lecture Notes, vol. 9, Amer. Math. Soc., Providence, RI, 1995.
- Hershy Kisilevsky and M. Ram Murty (eds.), *Elliptic Curves and Related Topics* (Sainte-Adèle, 1992), CRM Proc. Lecture Notes, vol. 4, Amer. Math. Soc., Providence, RI, 1994.
- Guido Mislin (ed.), *The Hilton Symposium 1993: Topics in Topology and Group Theory* (Montréal, 1993), CRM Proc. Lecture Notes, vol. 6, Amer. Math. Soc., Providence, RI, 1994.
- Joel S. Feldman, Richard Froese, and Lon M. Rosen (eds.), *Mathematical Quantum Theory I: Many-Body Theory and Group Theory* (Vancouver, 1993), CRM Proc. Lecture Notes, vol. 7, Amer. Math. Soc., Providence, RI, 1994.
- Donald A. Dawson (ed.), *Measure-valued Processes, Stochastic Partial Differential Equations and Interacting Systems* (Montréal, 1992), CRM Proc. Lecture Notes, vol. 5, Amer. Math. Soc., Providence, RI, 1994.
- M. Ram Murty (ed.), *Theta Functions. From the Classical to the Modern*, CRM Proc. Lecture Notes, vol. 1, Amer. Math. Soc., Providence, RI, 1993.
- Philip D. Loewen, *Optimal Control via Nonsmooth Analysis*, CRM Proc. Lecture Notes, vol. 2, Amer. Math. Soc., Providence, RI, 1993.
- Andrei L. Smirnov and Rémi Vaillancourt (eds.), *Asymptotic Methods in Mechanics*, CRM Proc. Lecture Notes, vol. 3, Amer. Math. Soc., Providence, RI, 1993.

AMS: *CRM Monographs*

- John Milton, *Dynamics of Small Neural Populations*, CRM Monogr. Ser., vol. 7, Amer. Math. Soc., Providence, RI, 1996.
- Ioannis Karatzas, *Lectures on Mathematics of Finances*, CRM Monogr. Ser., vol. 8, Amer. Math. Soc., Providence, RI, 1996.
- David Ruelle, *Dynamical Zeta Functions for Piecewise Monotone Maps of the Interval*, CRM Monogr. Ser., vol. 4, Amer. Math. Soc., Providence, RI, 1994.
- Andrew M. Bruckner, *Differentiation of Real Functions*, CRM Monogr. Ser., vol. 5, Amer. Math. Soc., Providence, RI, 1994.
- Eugene B. Dynkin, *An Introduction to Branching Measure-Valued Processes*, CRM Monogr. Ser., vol. 6, Amer. Math. Soc., Providence, RI, 1994.
- Maximilian Ya. Antimirov, Andrei A. Kolyshkin, and Rémi Vaillancourt, *Applied Integral Transforms*, CRM Monogr. Ser., vol. 2, Amer. Math. Soc., Providence, RI, 1993.
- V. Kumar Murty, *Introduction to Abelian Varieties*, CRM Monogr. Ser., vol. 3, Amer. Math. Soc., Providence, RI, 1993.
- Dan V. Voiculescu, Kenneth J. Dykema, and Alexandru Nica, *Free Random Variables*, CRM Monogr. Ser., vol. 1, Amer. Math. Soc., Providence, RI, 1992.

Les Publications CRM

- Paul Koosis, *Leçons sur le théorème de Beurling at Malliavin*, Les Publications CRM, Montréal, 1996.
- David W. Rand, *Concorder Version Three: Concordance Software for the Macintosh*, Les Publications CRM, Montréal, 1996 (user'guide and software).
- Decio Levi, Curtis R. Menyuk, and Pavel Winternitz, *Self-Similarity in Stimulated Raman Scattering* (Montréal, 1993), Les Publications CRM, Montréal, 1994.
- Jacques Gauvin, *Theory of Nonconvex Programming*, Les Publications CRM, Montréal, 1994.
- Rémi Vaillancourt, *Compléments de mathématiques pour ingénieurs*, Les Publications CRM, Montréal, 1993.
- Robert P. Langlands and Dinakar Ramakrishnan (eds.), *The Zeta Functions of Picard Modular Surfaces* (Montréal, 1988), Les Publications CRM, Montréal, 1992.

- Florin N. Diacu, *Singularities of the N-Body Problem*, Les Publications CRM, Montréal, 1992.
- Jacques Gauvin, *Théorie de la programmation mathématique non convexe*, Les Publications CRM, Montréal, 1992.
- Pierre Ferland, Claude Tricot, and Axel van de Walle, *Analyse fractale: Application Windows™ 3.x d'initiation aux ensembles fractals*, Les Publications CRM, Montréal, 1992 (user'guide and software).
- Stéphane Baldo, *Introduction à la topologie des ensembles fractals*, Les Publications CRM, Montréal, 1991.
- Robert Bédard, *Groupes linéaires algébriques*, Les Publications CRM, Montréal, 1991.
- Rudolf Beran and Gilles R. Ducharme, *Asymptotic Theory for Bootstrap Methods in Statistics*, Les Publications CRM, Montréal, 1991.
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- Véronique Hussin (ed.), *Lie Theory, Differential Equations and Representation Theory* (Montréal, 1989), Les Publications CRM, Montréal, 1990.
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- M. Ram Murty (ed.) *Automorphic Forms and Analytic Number Theory* (Montréal, 1989), Les Publications CRM, Montréal, 1990.
- Wendy G. McKay, Jiří Patera and David W. Rand, *Tables of Representations of Simple Lie Algebras. I. Exceptional Simple Lie Algebras*, Les Publications CRM, Montréal, 1990.
- Anthony W. Knapp, *Representations of Real Reductive Groups*, Les Publications CRM, Montréal, 1990.
- Wendy G. McKay and Jiří Patera and David W. Rand, *SimpLie User's Manual—Macintosh Software for Representations of Simple Lie Algebras*, Les Publications CRM, Montréal, 1990 (user'guide and software).
- Francis H. Clarke, *Optimization and Nonsmooth Analysis*, Les Publications CRM, Montréal, 1989.
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- Samuel Zaidman, *Une introduction à la théorie des équations aux dérivées partielles*, Les Publications CRM, Montréal, 1989.
- Lucien Le Cam, *Notes on Asymptotic Methods in Statistical Decision Theory*, Les Publications CRM, Montréal, 1974.

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- Yuri I. Manin, *Quantum Groups and Non-Commutative Geometry*, Les Publications CRM, 1988.
- Laurent Schwartz, *Semimartingales and Their Stochastic Calculus on Manifolds*, Presses de l'Université de Montréal, 1984.
- Yuval Ne'eman, *Symétries, jauges et variétés de groupe*, Presses de l'Université de Montréal, 1979.
- R. Tyrrell Rockafellar, *La théorie des sous-gradients et ses applications à l'optimisation, fonctions convexes et non convexes*, Presses de l'Université de Montréal, 1979.
- Jacques-Louis Lions, *Sur quelques questions d'analyse, de mécanique et de contrôle optimal*, Presses de l'Université de Montréal, 1976.
- Donald E. Knuth, *Mariage stables et leurs relations avec d'autres problèmes combinatoires*, Presses de l'Université de Montréal, 1976.
- Robert Hermann, *Physical Aspects of Lie Group Theory*, Presses de l'Université de Montréal, 1974.
- Mark Kac, *Quelques problèmes mathématiques en physique statistique*, Presses de l'Université de Montréal, 1974.
- Sybreen de Groot, *La transformation de Weyl et la fonction de Wigner: une forme alternative de la mécanique quantique*, Presses de l'Université de Montréal, 1974.

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- Pierre Ferland, Claude Tricot, and Axel van de Walle, *Fractal analysis user's guide. Introduction to fractal sets using Windows™ 3.x.*, Amer. Math. Soc., Providence, RI and Centre de recherches mathématiques, Montréal, 1994.

Research Reports

[CRM-2368] Luc Lapointe and Luc Vinet, Rodrigues formulas for the Macdonald polynomials, June 1996.

[CRM-2369] Jan Felipe van Diejen and Jasper V. Stokman, Multivariable q-Racah polynomials, June 1996.

[CRM-2371] Chi-Sing Lam, Jiří Patera and Robert T. Sharp, Generating functions for the Coxeter group H_4, June 1996.

[CRM-2372] Jean-Marc Lina and Pascal Drouilly, The importance of the phase of the symmetric Daubechies wavelets representation of signals, July 1996.

[CRM-2373] Zora Thomova, Pavel Winternitz and Wojciech J. Zakrzewski, Solutions of (2+1)-dimensional spin systems, August 1996.

[CRM-2374] Robert P. Langlands and Yvan Saint-Aubin, Aspects combinatoires des équations de Bethe, August 1996.

[CRM-2375] Igor V. Nikolaev, Flows with disjoint Q-sets, August 1996.

[CRM-2376] Igor V. Nikolaev, Foliations and umbilical points on surfaces, August 1996.

[CRM-2377] Sahbi Ayari and Serge Dubuc, Functional equations through subdivision algorithms, August 1996.

[CRM-2378] Jean-Marc Lina and Jason Scott, Adaptive shrinkage with complex Daubechies wavelets, August 1996.

[CRM-2379] Yuri Yu. Berest and Pavel Winternitz, Huygens' principle and separation of variables, September 1996.

[CRM-2380] Charles F. Dunkl, Intertwining operators of type B_N, September 1996.

[CRM-2381] Michel Blais and Brenda MacGibbon, Une approche par la théorie d'information d'un théorème limite pour les processus stochastiques réversibles, September 1996.

[CRM-2382] Sébastien Tremblay and Pavel Winternitz, Solvable Lie algebras with triangular nilradicals, September 1996.

[CRM-2383] Luc Frappat, Antonino Sciarrino, Stefano Sciuto and Paul Sorba, Anyonic realization of the quantum affine Lie superalgebra $U_q(\hat{A}(M-1,N-1))$, September 1996.

[CRM-2384] Abraham Broer, A vanishing theorem for Dolbeault cohomology of homogeneous vector bundles, September 1996.

[CRM-2385] Jan Felipe van Diejen, Confluent hypergeometric orthogonal polynomials related to the rational quantum Calogero system with harmonic confinement, September 1996.

[CRM-2387] Jacques Bélair, Stability analysis of an age-structured model with a state-dependent delay, September 1996.

[CRM-2423] Catherine Huber and Brenda MacGibbon, Lower bounds for estimating a hazard, July 1996.

[CRM-2436] Christian Janot and Jiří Patera, Simple physical generation of quasicrystals, October 1996.

[CRM-2437] Alfred Michel Grundland, Luigi Martina and Guy Rideau, Partial differential equations with differential constraints, October 1996.

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[CRM-2439] Malcolm R. Adams, John Harnad and Jacques C. Hurtubise, Darboux coordinates and Serre duality, 1996.

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FINANCIAL REPORT

The financial year of the CRM starts on June 1 and ends on May 31. The Financial Statement presents, on a cash-flow basis, the major expenses and income of the CRM during 1996-1997, as well as its financial position at the beginning and at the end of the period. The overall results have been broken down into three major column groups representing the following sources of financing: the National Science and Engineering Research Council of Canada (NSERC), the Fonds pour la formation de chercheurs et l'aide à la recherche du Québec (FCAR), and Other sources.

Major Sources of Income in 1996-97

Université de Montréal*	760,000
NSERC-Core	800,000
NSERC-NCM2 (600,000 - 480,000)	120,000
FCAR-Centre	210,750
FCAR-Equipment	70,225

* In addition, the UdeM provides office space, heating, electricity, etc.

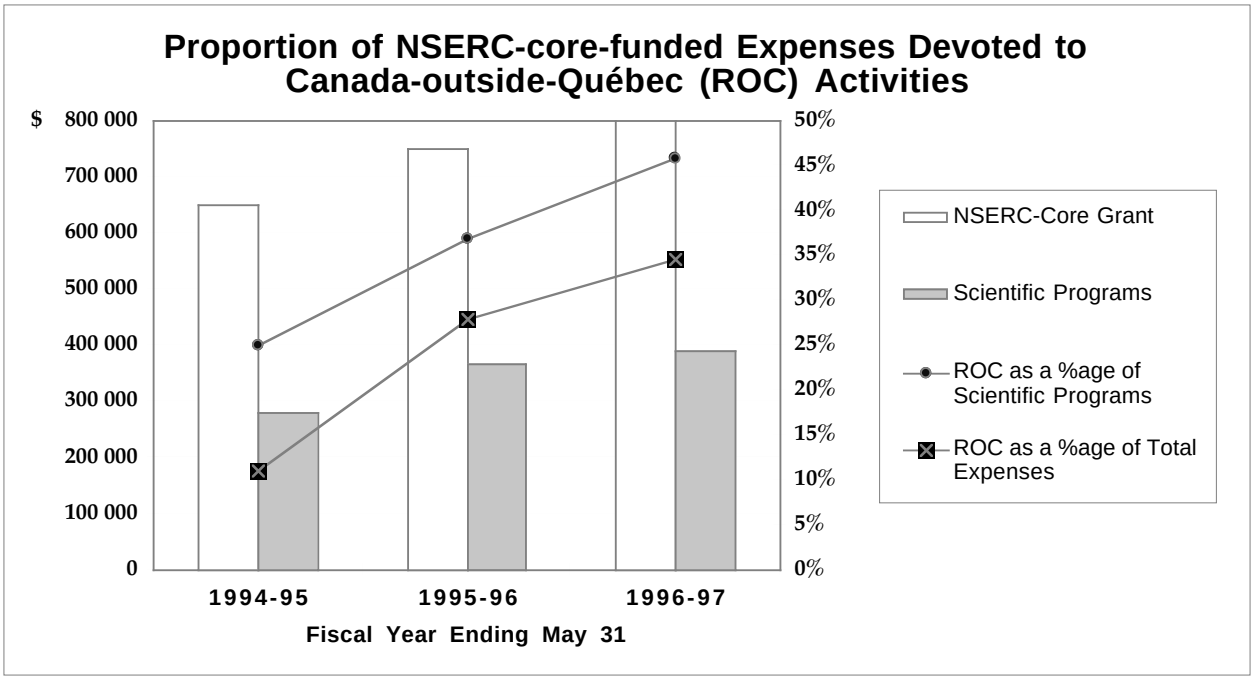
During 1996-1997 the CRM received **Income** (presented at the bottom of the Statement) from the following sources. ***NSERC-Core***: $800,000 in core operating grant to pursue its national mandate (a 6,7% increase over the $750,000 received the previous year); this level of funding is expected to be maintained over the next two years (1997-1999). ***NSERC-Other:*** the first $600,000 annual installment of a $3 million five-year research network grant for the newly created **nc*m*$_2$** (Network for Computing and Mathematical Modeling); **nc*m*$_2$** funding is being shared with four other research centres: the CERCA (Centre de recherche en calcul appliqué), the CIRANO (Centre interuniversitaire de recherche en analyse des organisations), the CRT (Centre de recherche sur les transports) and the GERAD (Groupe d'études et de recherche en analyse des décisions); **nc*m*$_2$** financial management is largely decentralized, and these four centres have been allocated $480,000 of the total $600,000; of the $120,000 remaining in the Financial Statement, $90,000 represents the share of the CRM, and $30,000 is a fund dedicated to centralized activities and which is being managed by the CRM on behalf of the **nc*m*$_2$**. ***FCAR-Centre***: the first $210,750 annual installment of a three-year operating grant from its Research Centre program (a 23,6% increase over the $170,500 received the previous year); such an increase in funding is quite remarkable given the 25% decrease in average FCAR funding for centres of the same category as the CRM. ***FCAR-Other***: $70,225 in a computer equipment grant to be used over the three-year period ranging from 1996 to 1999. ***OTHER Sources***: a substantial grant of $760,000 was received from the Comité d'étude et d'administration de la recherche (CEDAR) of the Vice-rectorat à la recherche of the Université de Montréal (a 1,5% decrease over the $771,300 received the previous year); other important sources of income include the Canadian Institute for Advanced Research (CIAR), the McConnell Foundation, and Dr. André Aisenstadt who is the CRM's major benefactor; finally, the CRM earns revenues from the publication of books in the American Mathematical Society (AMS) series and in its own home publications program, as well as from registration fees it charges for attending scientific activities.

The **Expenses** of the CRM are presented under three major categories: Scientific Activities, Publications, and Administration. Major items of the ***Scientific Activities*** include the *Scientific Personnel*: remuneration of Université de Montréal professors who perform research in-residence at the CRM, the expenses associated with the release of professors from Montréal-based universities so that they can perform work at the CRM, and the remuneration of postdoctoral researchers and summer students; the *Scientific Programs*: the 1996-1997 theme year in Combinatorics and Group Theory as well as some expenses from the previous theme year (Numerical and Applied Analysis), the Banff Summer School of 1996 related to the theme year in Combinatorics and Group Theory as well as the advance payment on the 1997 Summer School, the General Scientific Program, mainly constituted of contributions of the CRM to off-site scientific activities, the Colloquia and Seminar Series organized jointly with the Montréal-based Institut des Sciences Mathématiques (ISM), expenses associated to three prizes for excellence in the mathematical sciences: the André-Aisenstadt Prize, the Canadian Association of Physicists (CAP)-CRM Prize, and the CRM-Fields Institute Prize, and finally expenses related to guest researchers; the *Scientific Programs Personnel* directly involved in the management of the programs, and the *Research Support Personnel* directly involved in providing UNIX system services and preprint publications support to the researchers. The ***Publications*** item includes the remuneration of personnel dedicated to the Publications program as well as the direct expenses related to it. Finally, the ***Administra-***

tion portion of the Financial Statement includes: the remuneration of personnel of the Director's Office, Administration and Services to Researchers and Administrative Computer Systems, the expenses related to the meetings of the Advisory Committee and CRM-Fields Institute Coordinating Committee, the operating expenses, and computer equipment and maintenance expenses.

The **National Mandate** of the CRM is reflected in the NSERC-Core column of the Financial Statement labeled as *Rest of Canada* . Under this heading are singled out those NSERC-Core-funded expenditures of the CRM which occurred in Canada, but outside of Québec. Such expenses include the Summer School in Banff, numerous off-site scientific events sponsored by the CRM (often in collaboration with the Fields Institute and the Pacific Institute for the Mathematical Sciences), and the expenses related to non-Québec Canadians visiting the CRM in order to participate in its scientific programs. The ratio of such *Canada-outside-Québec* expenses to the overall NSERC-Core-funded expenses is: 46% for the Scientific Programs only (compared to 37% last year), and 35% (compared to 28% last year) for the total expenses funded by NSERC-Core. This ratio of 35% is well above the threshold of 25% once suggested by the CRM-Fields Institute Coordinating Committee in an earlier report.

Concerning the **Results and Financial Position**, the CRM has recorded an overall surplus of $169,690 during the period (compared to a deficit of $3,588 last year), which has increased its financial cushion from $107,736 at the beginning of the period to $277,426 at the end (a cushion representing 13% of its total income for the year). It is important to realize, however, that excluding the **nc*m*$_2$** funding by NSERC and FCAR equipment grant, the CRM overall surplus would have been $35,335 during the period, which would have increased its financial cushion from $107,736 at the beginning of the period to $143,071 at the end (a cushion representing 7% of its total income for the year, excluding **nc*m*$_2$** and FCAR equipment grants). The reason for the substantial surplus on the **nc*m*$_2$** fund is that the NSERC installment was received on March 31, 1997, only two months before the end of the 1996-1997 CRM fiscal year. The detailed results show that major accounts have been brought closer to equilibrium during the year. A surplus of $62,158 for the period has brought the CRM's NSERC-Core-account accumulated deficit back from $79,176 two years ago and $3,304 last year to a surplus of $58,854 this year. A surplus of $30,271 for the period has been allowed to bring the CRM's FCAR-account accumulated surplus position from $10,883 to $41,154, which will facilitate the allocation of large administrative expenses in future years. Finally, a deficit of $57,094 for the period has brought the CRM's OTHER-Sources-account accumulated surplus down from $204,670 two years ago and $100,156 last year to $43,062 this year.



Financial Statement

	NSERC - Core						
	Total	Rest of Canada	NSERC Other	FCAR Centre	FCAR Other	Other Sources	GRAND TOTAL
SCIENTIFIC ACTIVITIES							
Scientific Personnel							
Salaries						638 557	638 557
Partnerships	25 250			4 759			30 009
Release Time						18 981	18 981
Postdoctoral Researchers							
• CRM	31 833					333	32 166
• CRM/ISM	47 333	12 000				67 584	114 917
• CERCA/CRM	25 446					14 760	40 206
• GERAD/CRM	18 667						18 667
Summer Students and Other			2 500			10 000	12 500
Subtotal	**148 529**	**12 000**	**2 500**	**4 759**		**750 215**	**906 003**
Scientific Programs							
Numerical and Applied Analysis	856					15	872
Combinatorics and Group Theory	155 800	23 644				27 169	182 969
Summer School	57 456	57 456					57 456
Scientific Program - General	123 245	80 219				6 409	129 654
Colloquia and Seminar Series	13 156	1 938				4 761	17 916
Prizes	9 488	8 959				9 208	18 697
Guest Researchers and Other Expenses	30 577	6 925					30 577
Subtotal	**390 579**	**179 141**				**47 562**	**438 142**
Canada-outside-Québec Ratio:		**46%**					
Scientific Programs Personnel	125 658	57 634					125 658
Research Support Personnel				90 075			90 075
TOTAL SCIENTIFIC ACTIVITIES	**664 766**	**248 775**	**2 500**	**94 834**		**797 777**	**1 559 877**
Canada-outside-Québec Ratio:		**37%**					
PUBLICATIONS							
Personnel				69 971			69 971
Publications Expenses	6 829	1 669		8 098		2 839	17 766
TOTAL PUBLICATIONS	**6 829**	**1 669**		**78 069**		**2 839**	**87 737**
ADMINISTRATION							
Personnel						230 618	230 618
Advisory Committee	1 645	1 055				214	1 860
CRM/Fields Coordinating Committee							
Operating Expenses	60 336	3 615				12 537	72 873
Computer Equipment	4 265			7 576	53 370		65 211
TOTAL ADMINISTRATION	**66 246**	**4 670**		**7 576**	**53 370**	**243 369**	**370 562**
TOTAL EXPENSES	**737 842**	**255 113**	**2 500**	**180 479**	**53 370**	**1 043 985**	**2 018 176**
Canada-outside-Québec Ratio:		**35%**					
INCOME							
Operating Grants	800 000			210 750		814 780	1 825 530
Research Network, Equipment & Other Grants			600 000		70 225		670 225
Contributions and Sales			- 480 000			172 111	- 307 889
TOTAL INCOME	**800 000**		**120 000**	**210 750**	**70 225**	**986 891**	**2 187 866**
SURPLUS (DEFICIT)	**62 158**		**117 500**	**30 271**	**16 855**	**- 57 094**	**169 690**
Cash at the beginning of the period	**- 3 304**			**10 883**		**100 157**	**107 736**
Cash at the end of the period	**58 854**		**117 500**	**41 154**	**16 855**	**43 063**	**277 426**