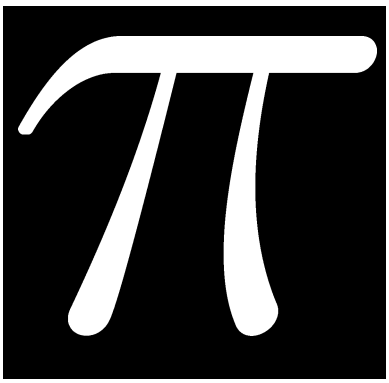

Pacific Institute for the Mathematical Sciences

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Annual Report 1998–1999

The Pacific Institute for the Mathematical Sciences is sponsored by:

- The Natural Sciences and Engineering Research Council of Canada
- The British Columbia Information, Science and Technology Agency
- The Alberta Science and Research Authority
- Simon Fraser University
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Foreword

Since the beginning of the operations of the Pacific Institute for the Mathematical Sciences (PIMS) in September 1996, the mathematical scientists of PIMS have collectively worked to build a unique institution within the international science community, to develop a wide array of innovative programmes to help it achieve the goals of its mandate and to secure funding to insure its continued existence.

In this annual report, we sketch our present level of development and outline PIMS' next year's programme to continue stimulating and coordinating the broad range of activities of mathematical scientists in Canada. We believe that the PIMS activities have successfully contributed to the building of a world class model for the Mathematical Sciences, a model that addresses simultaneously the imperatives of Research, of Education and of Technology Transfer. As will become apparent in this report, PIMS has already evolved into a leadership position on the Canadian national scene. There are two main reasons behind this early success:

- Its adaptive and highly effective distributed structure, sharing resources among several university sites, maintaining a flexible programme structure and empowering PIMS membership, has achieved a much higher level of activity than would otherwise be possible.
- Its innovative scientific, industrial and educational programmes have proved to be useful, timely, effective and rewarding on many levels.

The key to successful service to the community is the breadth, quality and originality of scientific activities initiated by PIMS.

- **Mathematical Thematic Programmes:** PIMS develops annually large-scale thematic programmes which provide a venue for leading international scientists to interact intensively with PIMS scientists over the course of the thematic period. Furthermore, these programmes provide an excellent opportunity for training young mathematical scientists as they can meet and work with leading experts in their fields of interest. The PIMS thematic programmes are often built around an area of particular strength within the PIMS community (e.g., *Probability theory* in 1997), with an emphasis on emerging areas (e.g., *Mathematical Economics and Finance* in 1998) or at the interface of different disciplines (e.g., *Mathematical Biology* in 1999) and in collaboration with other institutions (e.g., *Graph Theory and Combinatorial Optimization* in 2000 jointly with the Fields Institute).
- **Extra-thematic activities:** PIMS has deliberately chosen to avoid devoting all of its resources to such large-scale thematic programmes so that it might support a larger cross-subsection of its mathematical scientists. It does this through a wide range of scientific activities. For instance, the *Pacific Northwest Seminar Series* supports a number of smaller conferences and workshops, such as the Pacific Northwest Number Theory Seminar and the Cascade Topology Seminar, which bring together mathematical scientists from across the Pacific Northwest. PIMS has initiated a *Distinguished Lecture Series* which brings international authorities to one of the PIMS

sites and distributes their talks through teleconferencing. In addition, *The PIMS Distinguished Chair Programme* was recently created to support one visiting distinguished mathematical scientist at each one of PIMS' sites. The holder of the chair is expected to visit one of the PIMS universities for at least one month and give a mini-series of lectures.

- **Innovative Industrial Outreach Programmes:** Another important aspect of PIMS' vision is its commitment to strengthening the relationship between mathematical scientists at the five founding universities and their colleagues in the private and public sectors. In this technological age, industry is providing a wealth of interesting, challenging mathematical problems and, through PIMS' leadership, our mathematical scientists are discovering the richness of these problems and providing the needed expertise to solve them. PIMS hosts an annual week-long *Industrial Problem Solving Workshop* in which industrial scientists are invited to share problems relevant to their work.

  In this same vein, PIMS has created *Industrial Facilitator positions*, the role of which is to seek out sources of interesting mathematical problems in industry and connect them with experts within the PIMS community. One outgrowth of this is an *Industrial Mathematics Seminar* which is successfully bringing together scientists from industry and academia.

  The PIMS *Collaborative Industrial Programme* encourages teams of researchers –with common interests and complementary expertise– to develop around specific industrial projects and appropriate industrial partners. To help initiate, coordinate and support such research groups, PIMS provides these teams with financial support in the form of industrial graduate/postdoctoral fellowships , scientific support and industry-liaison services by the PIMS industrial facilitators, linkages with similar national initiatives as well as infrastructure and administrative support. Many of these teams are currently spearheading the development of MITACS: A Canadian Network of Centers of Excellence in the mathematical sciences (see below).

- **Training of highly qualified personnel:** Involving the PIMS community more fully in the international community leads to our commitment to train young mathematical scientists and provide them with excellent opportunities for growth. This year, PIMS will support over thirty postdoctoral fellows in collaboration with its industrial partners and its affiliated departments. Support programmes for graduate students at member institutions is also provided for participation in high-level scientific activities (e.g., the thematic programmes), training camps (e.g., the PIMS *Graduate Industrial Modeling Workshops*, the PIMS *Summer School in Industrial Fluid Dynamics*) as well as information programmes (e.g., The PIMS *Graduate Week-Ends*).

- **A pro-active involvement in mathematical education:** PIMS is committed to creating a more effective dialogue between mathematical scientists, educators and the general public. PIMS actively facilitates closer connections between mathematical scientists and educators at all levels through activities such as the *Conferences on Changing the Culture* (in BC), and Teachers Workshops (in Alberta) to support the Canadian Western Protocol. Some of PIMS best scientists have worked with educators and elementary school teachers to bring in new ideas for teaching mathematics. Also illustrative are the *Math Fairs, Evenings in Mathematics, Mathematics Unplugged events* and outreach programmes to high school students that PIMS is actively supporting. In universities, PIMS is sponsoring national conferences for undergraduate students and is also initiating a major drive to increase the total num-

bers of graduate students studying in the mathematical sciences at Canadian universities.

- **Communication and dissemination of mathematics:** The Pacific Institute places strong emphasis on the dissemination of both scientific information and general information about ongoing functions. In fact, the distributed nature of the institute, combined with the large number of scientific workshops, conferences, short courses, and thematic periods, seeks to involve a large proportion of its membership in scientific activities while ensuring that those activities reach a wide audience. Furthermore, PIMS actively supports the development of new technologies by investing in projects which aim to devise new tools for dissemination, and plans to put significantly more resources into technology development over the next four years.

  The traditional print medium is used to highlight the most significant PIMS events. *A quarterly newsletter*, containing the most important information about new activities, initiatives and awards, is distributed to more than 5000 scientists and organizations. PIMS annually prints over 3000 *posters* advertising PIMS events which are sent to universities and organizations across Canada and North America.

  The PIMS web page is the authoritative source for all PIMS information. For example, all registration forms can be filled and submitted electronically from the PIMS web page. Besides traditional printed form, preprints of work by PIMS' scientists will receive worldwide distribution electronically. Web based preprint servers are efficient mechanisms, both for the contributor and the receiver, and make research results available worldwide.

  The Digital Mathematics Archive is a digital collection of mathematical sources includes papers, letters, manuscripts, and computer rendered images and computations. One project is focusing on a digital version of Oliver Byrne's 1847 graphical edition of *Euclid's Elements* which also serves as a nucleus for local educational projects involving Euclid and geometry. Another project focusses on preserving the professional correspondence of the noted mathematician Prof. Robert P. Langlands of the Institute for Advanced Study (and graduate of UBC), as well as a selection of his previously unpublished and out of print work.

  Teleconferencing is an important tool for realizing the potential of the distributed Institute. For example, PIMS held a teleconferenced discussion with its scientists at all seven Alberta and BC universities within days of the acceptance of the MITACS NCE letter of intent to discuss the scientific and collaborative possibilities of the initiative. Scientific lectures by distinguished visitors are also available at all the PIMS' sites through teleconferencing. This technology has been instrumental in molding the group of mathematical scientists in western Canada into a tight-knit community.

  PIMS is currently working on a project to make PIMS Distinguished Lectures available on demand as *Streaming Video* from the PIMS web server. The audio files would need to be synchronised with image files of the speaker's transparency slides. We have already begun placing transparencies from the PIMS Distinguished Lecturer Series on the PIMS web page, but as of yet we do not have any streaming video files. The technical requirements of this service are currently under investigation. Demonstration versions of the software required for streaming video server are available free of charge.

  Also significant is the electronic journal *The Electronic Mathematician* which aims to use Internet technologies as a new tool for the communication of the mathematical sciences. As part of the PIMS sponsored UBC Sun SITE, this referred journal seeks mathematical submissions which con-

tain interactive elements, hypertext, graphics or other contents which prevent publication in more traditional form. In this way, we hope to illustrate how this new technology is a useful new medium for communication and publication. PIMS is also currently negotiating with various publishers the production of the *PIMS book series*. Guiding principles would be high scientific and literary standards, reasonable cover price, authors should hold copyright, wide distribution and advertisement, encourage productions of books which might not otherwise exist.

- **Communication with the Public:** Communicating new scientific developments and scientific thought to the public is a fundamental responsibility for all scientists. It increases public awareness of scientific issues and, in the long run, is the best method of ensuring the public supports scientific endeavours. PIMS is active in holding public lectures, presentations, and hands-on workshops. Activities with school children, and their teachers and parents reach thousands. As part of thematic periods, lectures aimed at the general public or a large subsubsection, are held. For example, the thematic programme on Mathematics of Economics and Finance (July-Aug. 1998), included lectures aimed at the financial business community, the derivatives community, and the general public.

- **Supporting all Canadian Mathematical Scientists:** PIMS is uniquely placed to address the particular needs of Alberta and British Columbia. Its first successes in this regard—the new cohesion among the mathematical scientists at the five founding universities and the dramatic increase in organized activities in western Canada in the last two years—are remarkable. However, the impact of PIMS goes beyond the strong roots planted in its local community as it more strongly connects its scientists to the larger mathematical sciences community throughout Canada and the world. PIMS facilitates the participation of all Canadian mathematical scientists in all its programmes and provides financial support for any Canadian graduate student recommended by his or her supervisor to attend any of PIMS thematic summers (which have their own introductory workshops and tutorials for graduate students) or participate in any of its innovative activities (e.g., the Industrial Problem Solving Workshops or the Graduate Industrial Modeling Camps). The PIMS *Graduate week-end* in Vancouver, the *International Mathematics Olympiad Training Camp* in Calgary and the *Canadian Undergraduate Mathematics Conference* demonstrate our commitment to providing opportunities for undergraduates from all Canadian universities.

- **Coordination with the CRM and the Fields Institute:** PIMS is also working closely with the Centre de Recherches Mathématiques and the Fields Institute to coordinate the activities of mathematical scientists at a national level including: Integrated thematic programmes, proposed joint scientific review panel and cross appointments on boards, development of a national education panel and co-operation on industrial partnership programmes. In particular, a common fund managed by a joint review panel, *The National Committee of the Mathematical Sciences Research Institutes*, including the deputy directors of the 3 institutes, has been established for the support of conferences and workshops in the mathematical sciences across Canada that fall outside of the main programme activities of the three institutes.

- **A National Centre of Excellence:** Again, in collaboration with the Fields Institute and the CRM, PIMS has developed a successful *Network of National Centers of Excellence in the Mathematical Sciences*: MITACS (short for "Mathematics of Information Technology and Complex Systems") was created to bring together lead-

ing researchers in the mathematical sciences to focus on the problems of mathematical modeling and management of large scale complex systems and the mathematics of information technology. PIMS was instrumental in getting substantial financial support from Western Canadian industry (including Ballard, Powertech, Powerex, BC Hydro, FinancialCad, etc) for the NCE. Such an industrial involvement has been essential for the success of this major initiative in the 1998 competition where MITACS was awarded $14.4 millions for the period 1999-2003.

- **Collaborations with Scientific Societies:** In recognition of its national objectives, PIMS devotes a significant amount of its current conference funding to scientific activities at regular meetings of the professional societies dedicated to the promotion of the mathematical sciences in Canada. These include the Canadian Mathematical Society (CMS), the Canadian Applied Mathematical Society (CAMS) and the Canadian Institute of Actuaries (CIA) among others.

- **Pacific Rim Connections:** PIMS also provides the Canadian mathematical sciences community with natural scientific links with Pacific Rim countries. For example, the *First Pacific Rim Mathematics Conference* was held in Hong Kong in January 98 and was jointly sponsored by PIMS, the Centre for Mathematical Sciences at the City U. of Hong Kong, and the Institute for Mathematics in Taiwan. In July 98, PIMS hosted the *First Pacific Rim Geometry Conference* to be held in North America. An ongoing agreement on summer schools and workshops in mathematical physics between the Asia–Pacific Centre in Korea and PIMS has recently been arranged. PIMS is coordinating *The First Canada-China Math congress*: the first event of the 3×3 Canada-China Mathematics Initiative, which is a collaboration of three universities in China (Beijing, TsingHua and Nankai) and four universities in Canada (UBC, UT, McGill, U. de Montréal). The aim of this conference – to be held in August 1999– is to initiate collaborative relationships between mathematicians in Canada and mathematicians in China. It is expected that over 100 Canadian mathematicians will attend the congress.

- **Financial Support:** During the 1997-1999 interim period, PIMS has received generous startup support from each of its member universities, and grants from the NSERC Research Partnership programme, the Alberta Science and Research Authority and the BC Science and Information Technology Agency. The Fields Institute and the Centre de Recherches Mathématiques have also contributed financial support. The 1998/99 operating budget of PIMS was $832K; as well PIMS received in-kind infrastructure support from the 5 founding universities estimated at $470K.

  PIMS will start its first year of full operations in April 1999. Funding commitments for the next 4 years (1999-2003) have been obtained from NSERC, the Alberta Science Research Agency, the BC Science and Information Technology as well as the PIMS founding universities. The 1999/2000 operating budget is $1,640K.

The Pacific Institute for the mathematical sciences is now well established as an energetic new advocate of Canadian science. Through the dedication of scientists in Alberta and BC, it has managed an extraordinary level of activity and innovation. In the following pages, we will describe PIMS' 1998 activities but also its 1999 strategy for continued growth in support of the mathematical sciences in Canada. We hope you will find it useful.

Nassif Ghoussoub, Director

Contents

Chapter 1

PIMS Management

1.1 Board of Directors

The Board of Directors has final responsibility for all aspects of the PIMS' operation. In particular, the Board ensures fiscal accountability, monitors the operation of the PIMS, and advises the Executive Committee.

- **Chair of the Board: Dr. Hugh Morris** holds a Ph.D in Mining Geology from the University of Witwatersrand, Johannesburg, South Africa and has 44 years of experience in the mineral industry. He is a fellow of the Royal Society of Canada and is Chair of the Society's Canadian Global Change Programme.

  From 1962 to 1979 he held a series of positions with Cominco Ltd. in its Exploration and Mining Departments in several Canadian locations, eventually becoming Director of Exploration for its worldwide activities. In 1979 Dr. Morris became associated with the E & B-Geomex Group of affiliated companies in Calgary, initially as President and Chief Operating Officer of Geomex Minerals Ltd., and in 1981, as President and Chief Executive Officer of E & B Canada Resources Ltd. Following the merger of the E & B-Geomex Group and Imperial Metals Corporation of Vancouver in May 1983, he was appointed Chairman and Chief Executive Officer of Imperial Metals and of three public companies within the Imperial Metals Group. He resigned from these positions in February 1993 to pursue other interests. Currently, he is a mineral industry consultant and board member of six Canadian public companies.

  Dr. Morris has demonstrated special interest in national and international scientific and professional associations. He is a member of NSERC's Council, a member of the Standing Finance committee of ICSU, and Chairman of the Board of Directors of the Lithoprobe Project. He is past-president of the Geoscience Council of Canada, a past-president of the Geological Association of Canada, and was also Treasurer of the Canadian Geological Foundation from 1987 to 1996. He is a member of the Geological Society of London, the Institute of Mining and Metallurgy, U.K., the Canadian Institute of Mining and Metallurgy, a member of the Association of Professional Engineers of British Columbia and a number of other scientific and professional associations.

- **Dr. Michael Boorman** received his PhD from University of Nottingham in 1964 and is a professor in the Chemistry Department at the University of Calgary. Currently he is the Dean of Science at the University of Calgary. Dr. Boorman's research activities are in *Inorganic Chemistry* and in *Heterogeneous Catalysis*.

- **Dr. Peter Borwein** is a Professor of Mathematics at Simon Fraser University and the Associate Director of the Centre for Experimental and Constructive Mathematics. Prior to joining Simon Fraser University in 1993 he was Professor of Mathematics at Dalhousie University. His research interests are in computational classical analysis and number theory.

  He was co-recipient of the Chauvenet Prize in 1993, the Hasse Prize in 1993 and the CUFA/BC Academic of the Year for 1996. Currently he is on the editorial boards of SIAM Review, the Journal of Approximation Theory, Constructive Approximation, The Ramanujan Journal, ETNA and Computational Complexity. He also co-edits the C.M.S/Wiley Series of Advanced Mathematics Books. He recently gave the Frontiers Lectures at Texas A& M in 1996 and the Nagel Lecture at the University of South Florida in 1996.

- **Dr. Bruce Clayman** received his PhD from Cornell University in 1968. He is currently a professor of Physics at Simon Fraser University as well as the Vice-President Research. His past administrative duties include Dean of Graduate Studies, President of the Canadian Association for Graduate Studies and Acting Dean of Science. He is a member of the Sigma Pi Sigma Physics Honour Society. His research interests include superconductors, impurity states in solids, and layered compounds. He

has published over 80 papers in refereed journals and refereed conferences.

- **Mr. Kenneth Foxcroft** served on the board of Directors of Factors Limited, Toronto Dominion Securities (USA) Inc., and of the Ontario Securities Advisory Commission. He has also held the positions of Chairman for Commodity Futures and President for the Forex Association of Canada. Presently, Mr. Foxcroft is the Deputy Chairman & Chief Trading Officer for TD Securities Inc.
- **Dr. Nassif Ghoussoub** is a Professor of Mathematics at the University of British Columbia. He did his undergraduate degree at the Lebanese University in Beirut and obtained his Doctorat détat in 1979 from the Universié Pierre et Marie Curie in Paris. He is a fellow of the Royal Society of Canada and is the current Director of the Pacific Institute for the Mathematical Sciences. His present research interests are in non-linear analysis and partial differential equations.

  He was the recipient of the Coxeter-James prize in 1990 and of a Killam senior fellowship in 1992. He was chair of NSERC's grant selection committee for mathematics in 1995-1996 and vice-president of the Canadian Mathematical Society from 1994 to 1996. He is on the editorial board of various international journals and is currently the co-Editor-in-Chief of the Canadian Journal of Mathematics.
- **Dr. Prubha Kundur** is the President and CEO of Powertech Labs Inc, a research subsidiary of BC Hydro. Powertech employes about 100 engineers, scientists and technologists at its labs in Vancouver BC. Dr. Kundar has been an adjunct faculty member at the University of Toronto and is currently an adjunct faculty member at the University of British Columbia.
- **Dr. Peter Lancaster** is a Professor Emeritus and Faculty Professor in the Department of Mathematics and Statistics of the University of Calgary. He has doctoral degrees from from the University of Singapore and the University of Liverpool, England, as well as five years experience in the aircraft industry in the 1950's. He came to Canada in 1962 and was elected to the Royal Society of Canada in 1984. His research interests are in matrix and numerical analysis especially as applied to vibrations, systems theory, and signal processing. He is the author or co-author of several texts and monographs and serves on a number of editorial boards. He has completed terms as Vice-President and as President of the Canadian Mathematical Society, and as Vice-President of the Canadian Applied Mathematics Society. He has also served (or is serving) on numerous committees of NSERC and the Royal Society of Canada.
- **Dr. Barry McBride** is the Vice-President Academic and Provost of the University of Britsih Columbia since 1999. He received his Ph.D. from the University of Illinois (Urbana) in 1970. He was the Dean of Science at the University of British Columbia from 1990 to 1999, Department Head of the Microbiology Department at UBC from 1986 to 1989 and Department Head of the Oral Biology Department at UBC from 1981 to 1986. He has consulted with Cominco, Energy Mines and Resources Canada, the National Institute of Health, USA and Ventures West. He is a member of many Professional Committees including the Medical Research Council (where he is also on the Executive Committee), the Standing Committee on Manpower (MRC), Scientific Advisory Council - Alberta Council - Alberta Heritage Foundation for Medical Research and the Canadian Institute for Advanced Research - Research Advisory Council. His major area of research is in ecology and pathogensis of the microbial flora of man with specific reference to pathogens of the mouth.
- **Dr. Edwin Perkins** is Professor of Mathematics at the University of British Columbia where he was first appointed as a postdoctoral fellow in 1979. He did is his undergraduate degree at U. of Toronto and obtained his doctoral degree from the U. of Illinois. His research interests in probability include the general theory of processes, Brownian motion, stochastic differential equations and partial differential equations, interacting particle systems, measure-valued diffusions and stochastic models in population genetics. He has won numerous awards for his research including the Coxeter-James Lectureship (1986)and G. de B. Robinson Award (1996) (Canadian Math. Society), the Rollo Davidson Prize (1983) (Cambridge U.) and a Steacie Fellowship (1992-93) (NSERC). He is a Fellow of the Royal Society of Canada and currently sits on the Academy of Science Council. He is presently on the editorial boards of the Canadian J. of Mathematics, the Annals of Applied Probability, the Annales de l'Institute Henri Poincaré, and Probability Theory and Related Fields. He has given several invited lectureships including an invited address at the 1994 International Congress of Mathematicians in Zurich.
- **Dr. Richard E. Peter** received a B.Sc. in Biology from The University of Calgary in 1965 and a Ph.D. from the University of Washington in 1969. Following postdoctoral research in Pharmacology at the University of Bristol, he took up an appointment in the Department of Zoology, University of Alberta, in 1971. Promoted to Professor in 1979, he served as Chairman of Zoology from 1983-1992, and became Dean of Science in 1992. His research is on the brain regulation of reproduction and growth in fish, an area in which he has over 260 publications. Dr. Peter has received numerous honours and awards, including the E.W.R. Steacie Memorial Fellowship in 1980, election as a Fellow of the Royal Society of Canada in 1985 and the Pickford Medal for outstanding contributions to compara-

tive endocrinology. A kit to induce spawning of farmed fish, based on his research, is marketed as OVAPRIM by Syndel Laboratories Ltd., Vancouver.

- **Dr. Claudine Simson** is Vice-President, Global External Research and Intellectual Property at Northern Telecom. She received her Doctorate in Aeronautical Engineering from the Université Paul Sabatier in Toulouse, France. She is also on the Board of Directors of the Fields Institute for research in the mathematical sciences.
- **Dr. Martin Taylor** has a BA in Geography from the University of Bristol (UK), and an MA and PhD from the University of British Columbia. He was appointed at McMaster in 1974. He was Chair of Geography (1991-1997), founding Director of the Institute of Environment and Health (1991-96), and Acting Vice-President Research (1994-95). His research and teaching interests focus on environmental health and health promotion issues. His ongoing projects include research on the psychosocial effects of environmental contamination and on community-based heart health promotion. He has authored one book and over 100 papers in peer-reviewed journals. He moved to UVic in July 1998 to be the University's first Vice-President Research as well as being a full professor in the Geography Department.

The *Steering Committee* of the Board consists of D. Peter (Chair), P. Borwein, N. Ghoussoub, P. Lancaster, M. Taylor and E. Perkins.

1.2 Scientific Review Panel

The Scientific Review Panel is responsible for:

- The review and selection of scientific programmes and determination of their funding levels
- The selection of the PIMS Postdoctoral Fellows and the PIMS Visiting Fellows
- Provide advice on long-term scientific planning for PIMS.
- **David Boyd (Chair)** received his Ph.D. in Mathematics from the University of Toronto in 1966. At that time he worked in harmonic analysis and in particular interpolation theory for rearrangement invariant spaces. Subsequently his work shifted into number theory, particularly the theory of Pisot and Salem numbers and Mahler's measure. He is particularly interested in the role of computation in pure mathematics. After his Ph.D., he spent a year at the University of Alberta, then moved to the California Institute of Technology where he spent the next four years, and finally moving to the University of British Columbia where he has been a Professor of Mathematics since 1974. He was awarded the 1978 E.W.R. Steacie Prize in Science for his work on Pisot sequences and Salem numbers. He was the Canadian Mathematical Society's Coxeter-James lecturer for 1979 and was elected to the Royal Society of Canada in 1980.
- **Richard Ewing** is Dean of the College of Science and Professor of Mathematics and Engineering at Texas A & M University. He also is Director of the Institute for Scientific Computation and the Academy for Advanced Telecommunications & Learning Technologies at Texas A & M. Prof. Ewing is an expert in scientific computation. His recent research deals with the multitude of problems that arise from numerical simulation and modelling of multiphase flow and transport in porous media as applied to ground water contaminants and reservoir modelling. He has an extensive background in consulting/advising with the public and private sector especially the petroleum industry.
- **Ronald Graham** is currently Chief Scientist of AT&T Research. He was President of the American Mathematical Society from 1993-95. His other current obligations include: membership of the Scientific Advisory Committee of the Santa Fe Institute, of the National Research Council, Mathematical Sciences Education Board, and of the Joint Policy Board on Mathematics. He is Treasurer of the National Academy of Sciences (1996-2000). Dr. Graham's academic awards include: Membership in the National Academy of Sciences and Fellowships in the American Academy of Arts & Sciences, the New York Academy of Sciences, and the American Association for the Advancement of Science. He was the Scientist of the Year, World Book Encyclopedia in 1981, and won the Polya Prize in Combinatorics in 1972, the Carl Allendorfer Award of the Math. Assoc. of America in 1990, a Lester Ford Award of the Math. Assoc. of America, in 1991, and the Euler Medal of the Institute of Combinatorics in 1994. Ron Graham's current mathematical interests include combinatorics, number theory, graph theory, discrete and computational geometry, theoretical computer science, and applications thereof. In all of these areas he has made fundamental contributions. He is also a very gifted juggler.
- **Wolfgang J. R. Hoefer** is a Professor of Electrical and Computer Engineering at the University of Victoria and holds the NSERC/MPR Teltech Industrial Research Chair in RF-Engineering. He is a fellow of the Institute of Electrical and Electronics Engineers (IEEE) and of the Advanced Systems Institute (ASI) of British Columbia. electromagnetics, numerical modelling of electromagnetic fields and structures, microwave and millimeter-wave circuit design, and microwave measurements.

Prof. Hoefer has been a visiting scientist or professor at AEG-Telefunken in Germany, the Communications Research Centre in Ottawa, and the Universities of Grenoble, Rome -Tor Vergata, Nice - Sofia Antipolis, Munich, and Duisburg. He is the managing editor of the International Journal of Numerical Modelling since 1988.

- **Richard M. Karp** was born in Boston, Massachusetts in 1935 and was educated at the Boston Latin School and Harvard University, where he received his Ph.D. in Applied Mathematics in 1959. From 1959 to 1968 he was a member of the Mathematical Sciences Department at the IBM Thomas J. Watson Research Center. From 1968 to 1994 he was a professor at the University of California, Berkeley. From 1988 to 1995 he was also associated with the International Computer Science Institute in Berkeley. In 1994 he retired from Berkeley and was named University Professor (Emeritus). In 1995 he moved to the University of Washington, where he has appointments in Computer Science and Molecular Biotechnology. The unifying theme in Karp's work has been the study of combinatorial algorithms. His 1972 paper "Reducibility Among Combinatorial Problems," demonstrated the wide applicability of the concept of NP-completeness. Much of his subsequent work has concerned the development of parallel algorithms, the probabilistic analysis of combinatorial optimization problems, and the construction of randomized algorithms for combinatorial problems. His current research is concerned with strategies for sequencing the human genome. Karp has received the U.S. National Medal of Science,Turing Award (ACM), the Fulkerson Prize(AMS and Math. Programming Society), the von Neumann Theory Prize(ORSA-TIMS), the Lanchester Prize (ORSA) the von Neumann Lectureship (SIAM) and the Distinguished Teaching Award (Berkeley). He is a member of the National Academy of Sciences and the National Academy of Engineering, and holds four honorary degrees.
- **Alistair Lachlan** obtained his Ph.D. from the University of Cambridge in 1964 and is currently a Professor of Mathematics at Simon Fraser University. Prof. Lachlan was elected as a Fellow of the Royal Society of Canada in 1974. He has served as the Vice-President of the Canadian Mathematical Society (1985–1987), was a member of the NSERC math GSC (1984–1987), was a member of the selection panel for speakers in Mathematical Logic at the 1990 ICM, and served on the steering committee for the CRM (1991–1995). He is and has been an editor for a number of journals including annals of pure and applied logic and the lecture notes in logic.
- **Bernard J. Matkowsky** presently holds the John Evans Chair in Applied Mathematics at Northwestern University. He received his Ph.D. from New York University in 1966. He was at Rensselaer Polytechnic Institute until 1978 and has been at Northwestern University since then. He is the editor of 7 journals (SIAM J. Appl. Math., European J. Appl. Math., Int'l. J. Wave Motion, Random and Computational Dynamics, J. Materials Synthesis and Processing, Int'l. J. SHS, Applied Math. Letters) and one book series (Springer Appl. Math. Sci. series). His honors include being a Fulbright-Hayes Fellow in 1972-1973 and a Guggenheim Fellow in 1982-1983. His research areas include asymptotic and perturbation methods for ordinary and partial differential equations, nonlinear stability and bifurcation theory, stochastic differential equations, and applications to fluid dynamics, elasticity, combustion, flame propagation, and solid state physics.
- **Robert V. Moody** is Professor of Mathematics at the University of Alberta. He received his Ph.D. from the University of Toronto in 1966 and spent most of his academic career at the University of Saskatchewan before coming to Alberta in 1989. He is best known for the discovery, independently with V. Kac, and subsequent investigations of the Kac-Moody Algebras, for which he was awarded the 1994-1996 Eugene Wigner Medal jointly with Kac. He has presented both the Coxeter-James Prize Lecture (1978) and the Jeffrey-Williams Prize Lecture (1995) to the Canadian Mathematical Society. He has served nationally on the Scientific Advisory Boards of both the Centre de Recherches de Mathematique and the Fields Institute for Research in the Mathematical Sciences, and on the Council of the Academy of Science, Royal Society of Canada.
- **Nicholas Pippenger** received his Ph.D. from MIT in Electrical Engineering in 1974. Prior to joining UBC Computer Science department as a professor in 1988, he was a staff member at IBM for sixteen years and at Draper Laboratories for three years. For his last two years at IBM he was an IBM Fellow. His other distinctions include a 1991 UBC Killam Research Prize, a 1983 IBM Outstanding Technical Achievement Award, and a 1981 IBM Outstanding Innovation Award. He has published over 90 research articles in the theory of computation and communication and discrete mathematics.
- **Gordon Slade** received his Ph.D. from the University of British Columbia, in Mathematics, in 1984. Before joining UBC Mathematics Department as a professor in 1999, he was a professor in the Mathematics department at McMaster University. He was the 1995 Coxeter-James Lecturer of the Canadian Mathematical Society, and was one of five Canadian mathematicians invited to give addresses at the 1994 International Conference of Mathematicians in Zurich. In joint work with T. Hara, he has given a rigorous proof of the long-standing conjecture that percolation (and also other important models in statistical physics) exhibit mean-field behaviour in high dimensions.

- **Gang Tian** received his Ph.D. from Harvard University in 1988. After positions at Princeton University and the State University of New York at Stony Brook, he went to the Courant Institute of Mathematical Sciences at New York University in 1991 as full professor. He is currently a professor in Massachusetts Institute of Technology. Prof. Tian is a recipient of the Alfred P. Sloan research fellowship (1991-1993). He presented a 45-minutes invited address at the International Congress of Mathematicians in Kyoto in 1990 and the Bergmann Memorial Lecture at Stanford University in 1994. The same year, he received the 19th Alan Waterman Award from the National Science Foundation. In 1996, Prof. Gang Tian received the Veblen Prize of the American Mathematical Society.

1.3 National Programme Committee of the Canadian Mathematical Sciences Institutes

This is a joint committee of the three Canadian Institutes in the Mathematical Sciences CRM, Fields and PIMS. It will administer most joint activities in the mathematical sciences and will make recommendations to the Directors of the three institutes. The mandate includes

- Allocating funds provided by the three institutes to support conferences and workshops in the mathematical sciences across Canada. These will primarily be activities that fall outside of the main purview of the three institutes.
- Allocating funds for the support of activities that are held at the meetings of the three Canadian mathematical science societies - Canadian Mathematical Society, Canadian Applied and Industrial Mathematical Society, Statistical Society of Canada.
- Annually coordinating the organization of three Institute Sessions to be held at the meetings of the Canadian Mathematical Society.
- Selecting graduate students to be supported to attend the scientific meetings of the National Societies.
- Coordinating international programmes and other ventures where it is advantageous for the three Institutes to act as a whole.

The committee consists of:

Chair Arvind Gupta, (CS, SFU), Deputy Director of PIMS
Deputy Director of CRM (TBA)
Deputy Director of the Fields Institute (TBA)
Francois Lalonde (Mathematics, UQAM)
Martin Barlow (Mathematics, UBC)
David Sankoff (CRM)

1.4 Executive Committee

The Executive Committee consists of the Director, the five Site Directors, and other members appointed by the Board as required. The Executive is responsible for the day to day management of the PIMS as delegated by the Board.
Director: N. Ghoussoub, (UBC, Mathematics)
A. Gupta (SFU, Computer Sciences)
F. Ruskey (UVic, Computer Science)
D. Rolfsen (UBC, Mathematics)
M. P. Lamoureux (UC, Math. & Stats.)
T. B. Moodie (UA, Mathematics)

1.5 Director's Office

Director: Nassif Ghoussoub
Deputy Director: Arvind Gupta
Scientific Executive Officer: Alexander Rutherford
Industrial Facilitator: Huaxiong Huang
Financial Officer: Katrina Soh
Education Coordinator: Klaus Hoechsmann
MITACS Administrator: Dorota Rygiel
Communication & System Manager: Thomas Uphill

1.6 Local Steering Committees

SFU

Site Director: Arvind Gupta
Admin. Assistant: Thomas Uphill

Jon Borwein (Math)
Malgorzata Dubiel (Math)
Brian Alspach (Math)
Peter Borwein (Math)
Sandy Dawson (Education)
Jim Delgrande (CS)
Lou Hafer (CS)
Kathy Heinrich (Math)
Pavol Hell (Math & CS)
Mary-Catherine Kropinski (Math)
Alistair Lachlan (Math)

UA

Site Director: T. Bryant Moodie
Admin. Assistant: Lina Wang
Industrial Facilitator: John Vardalas
Assistant to Indus. Facilitator: Andrew Kobos
Andy Bush (Earth & Atmospheric Sci)
Anthony Lau (Math Sci)
Gerda de Vries (Math Sci)
Peter Minev (Math Sci)
Russ Greiner (CS)

UBC

Site Director: Dale Rolfsen
David Austin (Math)
Uri Ascher (CS)
George Bluman (Math)
Elizabeth Croft (Mech Eng)
Uli Haussmann (Math)
Bent Jorgensen (Stat)
Ed Jull (ECE)
Leah Keshet (Math)
David (Kirkpatrick CS)
Robert Miura (Math)
Doug Oldenburg (Earth & Ocean Sci)
Dinesh Pai (CS)
Anthony Peirce (Math)
Ed Perkins (Math)
Martin Puterman (Commerce & Business Admin.)
Dale Rolfsen (Math)
Brian Seymour (Math)
Bernie Shizgal (Chemistry)
Douw Steyn (Geography)
Michael Ward (Math)
Matthew Yedlin (Geophysics and ECE)

UC

Site Director: Michael Lamoureux (Math & Stat)
Admin. Assistant: Joanne Longworth
Industrial Facilitator: Marc Paulhus
Rod Blais (Geomatics)
Ted Bisztriczky (Math & Stat)
Lisa Higham (CS)
Claude Laflamme (Math & Stat)
Peter Lancaster (Math & Stat)
Jon Rokne (CS)
Mike Stone (Math & Stat)
Gordon Sick (Management)
Peter Zvengrowski (Math & Stat)

UVic

Site Director: Frank Ruskey (CS)
Admin. Assistant: Kelly Choo
M. Fellows(CS)
P. van den Driessche (Math & Stat)
R. Illner (Math & Stat)
D. Leeming (Math & Stat)
M. Lesperance (Math & Stat)
G. Macgillivray (Math & Stat)
A. Sourour (Math & Stat)
W. Reed (Math & Stat)

Chapter 2

PIMS Scientific Personnel

2.1 PIMS Research Fellows

The PIMS Partnership Programme provides some teaching relief to mathematical scientists in the five founding universities to enable them to participate in, or organize PIMS projects. These include scientific programmes, joint projects with an industrial partner or educational projects. Funding and support for this programme is shared by PIMS and the participating departments.

- D. Austin (Math, UBC), 96/98
- D. Boyd (Math, UBC), 98/00
- N. Ghoussoub (Math, UBC), 96/00
- A. Gupta (CS, SFU), 96/00
- C. Laflamme (Math & Stat, UC), 97/98
- M. Lamoureux (Math & Stat, UC), 98/00
- T. B. Moodie (Math, UA), 98/00
- E. Perkins (Math, UBC), 96/98
- I. Putnam (Math, UVic), 97/98
- D. Rolfsen (Math, UBC), 96/99
- F. Ruskey (CS, UVic), 98/99
- A. Rhemtullah (Math. Sci, UA), 97/98

2.2 PIMS Postdoctoral Fellows

Seventeen PIMS Postdoctoral Fellowships have been awarded in 98/99 and twenty will be awarded in 99/00 to well deserving young researchers in the mathematical sciences who are within five years of their Ph.D. The nominations came from scientists affiliated with PIMS.

1998/1999 Academic Year

The selection in the 98/99 competition was made by David Boyd (Chair), Nick Pippenger (UBC), Pavol Hell (SFU), Robert Moody (U. Alberta), Rex Wesbrook (Calgary) and Pauline van den Driessche (Victoria).

1. **Malek Abdesselam**
   Department of Mathematics, UBC
   Sponsor: Joel Feldman
   Project: Renormalization Groups Method

2. **Stephen Kwok-Kwong Choi**
   Department of Mathematics, UBC
   Department of Mathematics and Statistics, SFU
   Sponsor: David Boyd, Peter Borwein
   Project: Number Theory

3. **Igor Fulman**
   Department of Mathematics, UC
   Sponsor: Berndt Brenken, Michael Lamoureux
   Project: Operator Algebras

4. **Marina Gavrilova**
   Department of Computer Science, U. Calgary
   Sponsor: J. Rokne
   Project: Theoretical and Applied Computational Geometry

5. **Eldad Hebber**
   Department of Computer Science, UBC
   Sponsor: U. Ascher
   Project: Geophysical & Medical imaging applications

6. **Rostyslav Hryniv**
   Department of Mathematics, UC
   Sponsor: Peter Lancaster
   Project: Spectral Theory of Differential and Abstract Operators, Operator Pencils, Mathematical

Physics

7. **Sadok Kallel**
Department of Mathematics, UBC
Sponsor: D. Sjerve
Project: Algebraic Topology

8. **Yves Lucet**
Department of Mathematics, U. Alberta
Department of Mathematics, U. Victoria
Department of Mathematics and Statistics, SFU
Sponsor: Jon Borwein, R. Poliquin, J. Ye
Project: Non-smooth Analysis

9. **Chunsheng Ma**
Department of Statistics, UBC
Sponsor: Harry Joe
Project: Multivariate Models

10. **David A. McNeilly**
Department of Mathematics, U. Alberta
Sponsor: G. Cliff, B. Moody, A. Weiss
Project: Fuchsian Groups

11. **Rua Murray**
Department of Mathematics, U. Victoria
Sponsor: Chris Bose
Project: Ergodic Theory and dynamical systems

12. **Martin Schlottmann**
Department of Mathematics, U. Alberta
Sponsor: R. V. Moody
Project: Quasicrystals

13. **Brett Stevens**
School of Computing Sciences, SFU
Sponsor: Pavol Hell
Project: Combinatorial Block Designs

14. **John Michael Stockie**
Department of Mathematics and Statistics, SFU
Sponsor: R. Russell
Project: Numerical Analysis, Applied Maths.

15. **Holger Teismann**
Department of Mathematics, U. Victoria
Sponsor: Reinhard Illner
Project: Mathematical Physics

16. **Arthur Vartanian**
Department of Mathematics, U. Alberta
Sponsor: Misha Kovalyov
Project: Applications of the Inverse Scattering Method

17. **Bruce Watson**
Dept. of Maths & Stats, U. Calgary
Sponsor: P. A. Binding
Project: Direction of inverse problems for multi-parameter systems

1999/2000 Academic Year

The selection in the 1999/2000 competition was made by David Boyd (Chair), Nick Pippenger (UBC), Charmaine Dean (SFU), Robert Moody (U. Alberta), Rex Wesbrook (Calgary) and Pauline van den Driessche (Victoria).

- **Ricardo Carretero**
Department of Mathematics and Statistics, SFU
Sponsor: Keith Promislow
- **Michael Segal**
Department of Computer Science, UBC
Sponsors: David Kirkpatrick, Jack Snoeyink
- **Sujin Shin**
Department of Math. and Statistics, UVic
Sponsors: Christonpher Bose, Ian Putnam
- **Konstantin Zarembo**
Department of Physics, UBC
Sponsor: Gordon Semenoff
- **Alexandra Chavez-Ross**
Department of Mathematics
Sponsor: Leah Keshet
- **Madhu Nayakkankuppam**
Department of Mathematics
Sponsors: Philip Loewen, Jonathan Borwein, Rene Poliquin
- **Ulrike Stege**
Department of Computer Science, UVic
Sponsors: Mike Fellows, Wendy Myrvold, Valerie King
- **Bret Stevens**
Department of Mathematics and Statistics, SFU
Sponsor: Brian Alspach
- **Ladislav Stacho**
School of Computer Science, SFU
Sponsor: Tom Shermer
- **Siva Athreya**
Department of Mathematics, UBC
Sponsors: Edwin Perkins, Martin Barlow, John Walsh
- **Igor Fulman**
Department of Mathematics, UCalgary
Sponsors: B.A. Brenken, Michael Lamoureux
- **Brad McNeney**
Department of Mathematics and Statistics, SFU
Sponsor: Charmaine Dean

- **Tahir Choulli**
  Department of Mathematics, UCalgary
  Sponsor: Larry Bates
- **Gengsheng Qin**
  Department of Mathematics, UVic
  Sponsor: Mon Tsao
- **Vladimir Bolotnikov**
  Department of Mathematics, UCalgary
  Sponsor: Paul Binding
- **Sam Lightwood**
  Department of Mathematics, UVic
  Sponsors: Christopher Bose, Ian Putnam
- **Miro Powojowski**
  Department of Geography, UCalgary
  Sponsor: Laurence Bentley
- **Ioan Bucataru**
  Department of Mathematics, UAlberta
  Sponsor: Peter Antonelli
- **Bert Wiest**
  Department of Mathematics, UBC
  Sponsor: Dale Rolfsen

2.3 PIMS Industrial Fellowships

Jointly supervised by PIMS scientists working in concert with their industrial counterparts, PIMS postdoctoral fellows split their time between the university and the company, exchanging intellectual ideas between these two domains. PIMS' PDFs are expected to participate in industrial workshops and conferences. They will act as the conduit for dissemination of knowledge between the industrial partner and the university research group. The Fellows submit an annual report to the Director outlining research and industrial activities including a list of reports and papers published as a result of these activities. We expect that the industrial facilitators will interact extensively with the PDFs. Industrial PDFs are also expected to actively participate in the PIMS Industrial Forum. The following projects have been supported in 1998/99.

1. **Petr Lisonek**
   Industrial Partner: Waterloo Maple
   Sponsor: Michael Monagan (CECM, SFU)
   Project: Simplification in Computer Algebra Systems

2. **D. Calistrate**
   Industrial Partner: Pan Canadian Petroleum Ltd
   Sponsors: C. Laflamme, M. Lamoureux and R. Aggarwala (Calgary)
   Project: Acoustic Oil-well Soundings

3. **P. Marechal**
   Industrial Partners: Siemens
   Sponsors: A. Celler (Vancouver General Hospital) and J. Borwein (SFU)
   Project: Medical Imaging

4. **M. Solomonovich**
   Industrial Partner: Canadian Rural Restructuring Foundation
   Sponsor: Freedman (U. Alberta)
   Project: New Rural Economy

5. **J. Cheng**
   Industrial Partner: Siemens
   Sponsor: Greiner (U. Alberta)
   Project: Bayesian Networks

6. **R. G. Scharein**
   Industrial Partner: Sun Microsystems
   Sponsors: D. Rolfsen and W. Casselman (UBC)
   Project: KnotPlot

7. **Yuri Shkolnikov**
   Industrial Partner: RITA Labs
   Sponsor: Gordon Sick and P. Zvengrowski (U. Calgary)
   Project: Risk Management

8. **Chris Jessop**
   Industrial Partner: Geological Survey of Canada
   Sponsor: R. Blais (U. Calgary)
   Project: Geological Modelling

9. **Rasheed Ait Haddou**
   Industrial Partner: College of Chiropractors of Alberta
   Sponsors: W. Herzog, P. Binding, L. Bos, and K. Salkauskas (U. Calgary)
   Project: Articular Joint Mechanics, Force-sharing Among Synergistic Muscles

The 1999 competition is still underway and is now part of the Collaborative Industrial Programme. PIMS expects to fund eight projects in the provinces of Alberta and British Columbia during 1999/2000.

2.4 PIMS Industrial Facilitators

PIMS industrial facilitators are scientists who spend time interacting with both university researchers and industrial partners. This provides industry with contact persons who have expertise in the various research groups at the five universities. The facilitators also work closely with the coordinators of all industrial workshops, industrial PDF's and PIMS administrators. In particular, early responsibilities include organizing the *Industrial Problem Solving Workshops* as well as the *Graduate Industrial Math Modelling Camps.* They have also initiated several industrial projects for PIMS members. Current facilitators are

- **Dr. Marc Paulhus**, University of Calgary (Part-time, 98/99).
- **Dr. Huaxiong Huang**, Director's Office, PIMS (Full-time, 98/99).
- **Dr. John Vardalas**, University of Alberta (Part-time, 98/99).

Chapter 3

PIMS Thematic Scientific Programmes: 1998–2000

PIMS plans and organizes its thematic periods in coordination, and sometimes in collaboration, with the Fields Institute and the Centre de Recherches Mathematiques. The first PIMS thematic summer in 1997 dealt with *Probability Theory and its applications*. The second was on *Mathematical Economics and Finance* in 1998. The 1999 Thematic Summer will be on *Mathematical Biology* while *Combinatorial Optimization and Graph Theory* will be the subject in the year 2000.

3.1 Mathematical Economics and Finance, July-August, 1998

Programme Committee: Ivar Ekeland (Université Paris-Dauphine), J. J. Laffont and J. C. Rochet ((Université des Sciences Sociales, Toulouse), Hervé Moulin (Duke University), John Weymark, (University of British Columbia), and W. Ziemba (University of British Columbia)

A group of activities dealing with mathematical problems arising in economics and finance were held. The second PIMS thematic summer consisted of three workshops and three conferences dealing with mathematical problems arising in the social sciences, economics and finance, as well as a Tutorial session and a Seminar for institutional investors.

Workshop on Mathematical Methods and Models for Social Choice and Distributive Justice, July 2, 7–9, 1998

Organisers: Hervé Moulin (Duke University), John Weymark (University of British Columbia)

Social choice theory is concerned with analyzing the properties of actual procedures for making collective decisions and with the design of collective decision procedures that satisfy various normative criteria and feasibility constraints. The subject includes such topics as voting rules, committee decision-making, and bargaining. Social choice theory also provides an analytic framework for studying distributive justice in problems of resource allocation (such as how to equitably share the costs of a facility among its users and how to measure income inequality).

This workshop provided a mini-course in social choice theory and related issues of distributive justice, with special emphasis on topics that illustrated the diverse branches of mathematics that this subject draws upon (such as algebra, analysis, topology, functional equations, game theory, graph theory, measurement theory, and majorization theory).

The following nine introductory two-hours

lectures given were designed to be of benefit to both the specialist and the nonspecialist:

- **Donald Campbell** (College of William and Mary): "Arrovian Social Choice"
- **Yves Sprumont** (Université de Montréal): "Strategy-Proof Mechanisms"
- **Bhaskar Dutta** (Indian Statistical Institute, Delhi Centre): "Implementation Theory"
- **Luc Lauwers** (Katholieke Universiteit Leuven): "Topological Social Choice"
- **Michel Le Breton** (GREQAM and Université de la Méditerranée): "Choice from Tournaments"
- **William Thomson** (University of Rochester): "Axiomatic Theory of Bargaining"
- **Walter Bossert** (University of Nottingham): "Utility Theory, Social Choice, and Inequality Measurement"
- **Hervé Moulin** (Duke University): "Rationing Methods"
- **Eric Friedman** (Rutgers University): "Cost Sharing Methods"

Fourth International Meeting of the Society for Social Choice and Welfare, July 3–6, 1998

Organisers: Charles Blackorby (UBC), David Donaldson (UBC), Hugh Neary (UBC), and John Weymark (Chair, UBC)

This conference celebrated Professor Mirrlees' recent Nobel Prize and the twenty-fifth anniversary of the Gibbard-Satterthwaite Theorem. One-hundred and ninety-two contributed papers were presented in parallel sessions separated into sixty-four sections. The following keynote speakers at this conference have all made fundamental contributions to the study of social institutions when individuals use private information strategically.

Plenary Speakers:

- **Allan Gibbard** (University of Michigan): "Social Choice: What are the Questions?"
- **James A. Mirrlees** (Cambridge University): "Economic Policy and Economic Politics"
- **Herve Moulin** (Duke University): "Random Priority: A Probabilistic Resolution of teh Tragedy of the Commons"
- **Mark A. Satterthwaite** (Northwestern University): "Competitive Markets and Strategy-Proofness"
- **Hervé Moulin** (Duke University): Random Priority: A Probabilistic Resolution of the Tragedy of the Commons.

Summer Conference on Industrial Organisation, July 10–11, 1998

Organiser: Thomas Ross (UBC)

This conference was a continuation of a series of summer industrial organisation conferences which began in 1987 at Carleton University. Since 1993, the conferences have been hosted by the Policy Analysis Division of the Faculty of Commerce and Business Administration at the University of British Columbia. The following six lectures were given:

- **Andrew Daughety** and **Jennifer Reinganum** (Vanderbilt University): "On the Economics of Trials: Adversarial Process, Evidence and Equilibrium Bias."
- **Shane Greenstein** (Northwestern University): "America On and Off Line: The Geography of the US Internet Access Industry."
- **Joseph Harrington** (Johns Hopkins University): "Organisational Structure and Innovation in a Multi-Unit Firm."
- **Tom Hubbard** (University of California at Los Angeles): " Technological and Organisational Change in the Trucking Industry."
- **Randall Kroszner** (University of Chicago): " What Drives Deregulation? Economics and Politics of the Relaxation of Branch Banking Restrictions."
- **Matthew Turner** (University of Toronto): "Optimal Quota Programs."

Workshop on Design of Markets and Organizations Under Incomplete Information, July 13–17, 1998

Organiser: J. C. Rochet (Université des Sciencces Sociales, Toulouse).

Mechanism design theory is concerned with the design of social decision procedures when economic agents have private information and use it strategically.

This workshop surveyed mechanism design theory in a way that was accessible to non-economists and illustrated the power of the theory by studying four kinds of applications: auctions, trading mechanisms, nonlinear pricing, and the design of organizations. The following five lecture series (5 hours each) were given:

- **Philippe Choné** (ENSAE) and **Jean-Charles Rochet** (Université des Sciences Sociales, Toulouse): "Ironing, Sweeping, and Multidimensional Screening"
- **Ken Hendricks** (University of British Columbia) and **Robert Porter** (Northwestern University): "Empirical Methods in Auctions"
- **Jean-Jacques Laffont** (Université des Sciences Sociales, Toulouse): "Contract Theory with Adverse Selection"
- **David Martimort** (Université des Sciences Sociales Toulouse): "Theory of Bureaucracy"
- **Lars Stole** (University of Chicago): "Competition in Nonlinear Prices"

Recent Developments in Mathematical Economics, July 20–23, 1998

Organisers: I. Ekeland (Université de Paris-Dauphine), J. Weymark (UBC)

Recent developments in economic theory have required the use of advanced mathematical techniques and have raised many interesting mathematical problems. This workshop served to provide an introduction to several areas of economic research that have been the subject of much recent activity and in which progress has been made using mathematical techniques. The following eight lecture series (4 hours each) were given:

- **Susan Athey** (Massachusetts Institute of Technology): "Recent Advances in Comparative Statics: Theory and Applications to Games of Incomplete Information."
- **Ivar Ekeland** (Université de Paris-Dauphine): "Disaggregation Problems in Consumer Theory: A Partial Differential Equations Approach."
- **Ken Judd** (Stanford University), "Numerical Methods in Economics."
- **Robert McCann** (Brown University), "Optimal Transportation, Hierarchical Structures, and Incentive Compatibility".
- **Richard McKelvey** (California Institute of Technology) and Andrew McLennan (University of Minnesota): "Computation of Equilibria in Finite Games."
- **Andreau Mas-Colell** (Universitat Pompeu Fabra): "Adaptive Adjustments in Games."
- **Philippe Mongin** (THEMA, Université de Cergy-Pontoise), "Logic and the Foundations of the Theory of Games and Decisions."
- **Jeroen Swinkels** (Washington University): "Evolutionary Game Theory."

Conference on Stochastic Programming, August 8–16, 1998

Organising Committee: William Ziemba (Chair), Roger Wets (Co-Chair), Andrzej Ruszcynski (COSP Chair), Jitka Dupacova (Eastern European Contact Person), Alan King (COSP Meeting Committee Chairman), Leonard MacLean, Maurice Queyranne, Terry Rockafellar, Gordon Sick, and Andrew Turner.

This conference consisted of three programmes: a preliminary tutorial programme; a main programme and a followup seminar.

Tutorial Programme, August 8–9, 1998

Organised by Julia Higle, this tutorial served as a prelude to the main programme for students and newcomers to the field. The following six lecturers were given:

- **Chanaka Edirishinghe** (University of Tennessee): "Bounding techniques in stochastic programming."
- **Julia Higle** and **Suvrajeet Sen** (University of Arizona): "Modeling in stochastic programming using a case study approach."
- **Janos Mayer** (University of Zürich): "Chance constrained programming."
- **Rüdiger Schultz** (Humbolt University): "Stability in stochastic programming."
- Maarten van der Vlerk (University of Gröningen): "Stochastic integer programs."
- **Stein W. Wallace** (Norwegian University of Science and Technology): "Introduction and overview of stochastic programming."

Main Programme, August 10–14

Most practical decision problems involve uncertainty. Stochastic programming is the study of practical procedures for decision making under uncertainty over time. This conference discussed theory and computations in general settings and applications in many areas such as financial modelling, asset-liability management, risk control, bond portfolio management, currency modelling, transportation, energy planning, production planning, telecommunications, forest and fishery harvest management, energy-economic planning and other areas.

The following plenary talks were given in addition to several smaller sessions:

- **Zvi Artstein** (Weizmann Institute of Science): "Gains of information in stochastic programming."
- **Ron Dembo** and **Dan Rosen** (Algorithmics Inc.): "Experiences at Algorithmics using stochastic programming for risk management."
- **Michael Dempster** (Cambridge University): "Dynamic sampling algorithms."
- **Chanaka Edirisinghe** (University of Tennessee): "Bounds and approximations for multiperiod stochastic programming."
- **Wim Klein Haneveld** and **Maarten vander Vlerk** (University of Groningen): "Stochastic integer programming."
- **Julia Higle** and **Suvrajeet Sen**: (University of Arizona): "Statistical approximation in linear programming."
- **Leonard MacLean** (Dalhousie University) and **William T. Ziemba** (University of British Columbia): "Growth versus security tradeoffs in dynamic investment analysis."
- **John Mulvey** (Princeton University): "Solving many similar large scale stochastic programs in asset/liability management."
- **Georg Plug** (University of Vienna): "Error estimates of sampling."
- **Andras Prekopa** (Rutgers University) "Probabilistic programming."
- **R. Tyrell Rockafellar** (University of Washington): "Duality in stochastic programming."
- **Andrzej Ruszczynski** (Rutgers University): "Large scale stochastic programming algorithms and computational experiences."
- **Andy Turner** (The Frank Russell Company): "Development and use of stochastic programming at the Frank Russell Company."
- **Roger J-B Wets** (UC Davis): "Statistical estimation and stochastic programming."
- **Stavros Zenios** (University of Cyprus): "Solving large scale stochastic programs in mortgage backed security analysis."

Asset and Liability Management Seminar for Institutional Investors, August 14–16

Organised by John Mulvey and William Ziemba, this seminar covered many aspects of asset and asset-liability management modelling. The chosen speakers were a blend of academics with investment and consulting experience and high level practitioners and researchers from leading financial institutions. Topics discussed included: mean variance analysis; fixed income investments; currency and asset price modelling; stochastic programming models of asset and asset-liability management problems for financial institutions and individuals; factor and stock ranking models; exotic option pricing; stochastic control and capital growth models; risk measures and value at risk and related overall risk control models.

In all, the following thirty-eight lectures were given:

- **Jitka Dupacova** (Charles University) and **Marida Bertocchi** (University of Bergamo): "Bond portfolio management in Italy."
- **Markus Rudolf** (Swiss Institute of Banking), and **William T. Ziemba** (University of British Columbia): "Intertemporal surplus management."
- **Roy Kouwenberg** and **Ton Vorst** (Eramus University): "Scenario generation and stochastic programming in ALM."
- **Yuan-Au Fan** (Frank Russell Company): "The Daido Model."
- **Cees Dert** (ABN-AMRO and Fee University of Amsterdam): "A multistage chance constrained programming approach to asset liability."
- **Elio Canestrelli** (University of Venice): "Analytical and numerical approaches in multidimensional stochastic processes applied to financial investments."
- **Arjan Berkelaar** (Econometric Institute Erasmus: "Downside-risk measures and the casino effect and its implications for financial risk-management."

- **Marc C. Steinbach** (Zonrad-Zuse-Zentrum für Informationstechnik): "Recursive direct optimization in financial multistage stochastic programs."
- **D. Kramkov** and **W. Schachermayer** (University of Vienna): "The asymptotic elasticity of utility functions and optimal investment in incomplete markets."
- **Chris Hensel** (Frank Russell Company): "Fundamentals of asset allocation: Russell's approach."
- **Richard Grinold** (Barclays Global Investors): "Beyond mean variance: using expected utility with entire return distributions."
- **Sanjiv Das** (Harvard Business School): "International portfolio choice with stochastic correlations."
- **Karl Frauendorfer** and **Michael Schuerle** (University of St. Gallen): "Interest rate models in stochastic optimization."
- **Stavros Zenios** (University of Cyprus): "Asset and liability management for fixed income securities."
- **Jan Hoffmann** (Math Consulting Group AG): "Investing reinvested: the management of fixed income securities through stochastic optimization."
- **Jitka Dupacova** (Charles University, Prague): "Scenarios for bond portfolios."
- **Eckhard Platen** (University of Technology, Sydney): "Continous time modelling of interest rates."
- **Tassos Mallaris** (Loyola University of Chicago) and **Marco Corazza** (University of Venice): "Multifractity in FX markets."
- **Ken Kortanek** and **V. G. Medvedev** (University of Iowa): "Replicating thinly traded with actively traded options."
- **Michael Dempster** (University of Cambridge) and **Eric Thorlacius** (Falcon Asset Management): "Stochastic simulation of economic variables and returns: the Falcon asset model."
- **Alan King** (IBM Research): "Efficient frontiers for multistage ALM problems."
- **Steve Murray** and **Andrew Turner** (Frank Russell Company): "Stochastic programming ALM in practice for clients with special constraints and problems."
- **John Mulvey** (Princeton University): "Experiences with the Towers Perrin Model."
- **Michael Dempster** (Cambridge University): "Risk management of option adjusted portfolios."
- **Eric Reiner** (Union Bank of Switzerland): "Pricing exotic options for alternative stochastic processes."
- **David Edelman** (University of Wollongong): "A stochastically subordinated log-stable price model for share price returns."
- **Wayne Ferson** and **Andrew Siegel** (University of Washington): "The efficient use of conditioning information in portfolios."
- **William T. Ziemba** (University of British Columbia): "U.S. and Japanese factor models."
- **Adam Berger** (Lattice Financial, LLC) and **John Mulvey** (Princeton University): "Asset-liability management for individuals."
- **Steve Murray** (Frank Russell Company): "A model for individual asset liability management in the Italian context."
- **Markku Kallio** (Helsinki School of Economics): "An asset management model for a Finnish Insurance Company."
- **Michael Brennan** (University of California, Los Angeles): "The role of learning in dynamic portfolio decisions."
- **Stanley Pliska** (University of Illionois at Chicago) and **Tomasz Bielecki** (Northeastern Illinois University): "Risk sensitive dynamic asset management."
- **Robert Grauer** (Simon Fraser University) and **Nils Hakansson** (University of California, Berkeley): "On naive approaches to timing the market: the empirical probability assessment approach with an inflation adapter."
- **Leonard MacLean** (Dalhousie University) and **William Ziemba** (University of British Columbia): "Capital growth with security."
- **Stewart Hodges** (University of Warwick): "A generalization of the Sharpe ratio and its applications to valuation bounds and risk measures."
- **David Heath** (Cornell University): "What makes a good risk measure?"
- **Ron Dembo** and **Dan Rosen** (Algorithmics Inc.): "Algorithmics' value at risk models."

Panel Discussions, Aug. 11 and Aug. 14

- Panel 1: John Mulvey and Roger Wets (organizers)– Experiences with and comparisons of solution techniques for solving large scale stochastic programs
- Panel 2: John Birge and Stein W. Wallace (organizers)– Where the field is going, future developments, key research areas, unsolved problems.

3.2 Mathematical Biology, June–August 1999

Organisers: Fred Brauer (University of Wisconsin and University of British Columbia), Leah

Keshet (University of British Columbia), Yue-Xian Li (University of British Columbia), Robert M. Miura (University of British Columbia), Pauline van den Driessche (University of Victoria), Marc Mangel (University of California, Santa Cruz), David Sankoff (Université de Montréal), Gerda de Vries (University of Alberta), Michael Waterman (University of Southern California)

Mathematics has been used in many branches of biology for centuries. However, as a separate discipline, mathematical biology has been recognized only over the past few decades. Mathematical biology is as diverse as are the areas making up biological and medical sciences. These areas encompass all aspects of life including populations at all levels from animal to microbial, epidemics, ecology, physiology including neurobiology, cardiology, endocrinology, renal physiology, muscle physiology, and biofluiddynamics such as blood flow and air movements in the lungs, cell biology, biochemistry, molecular biology, morphogenesis, diseases including cancer, HIV/AIDS, Parkinson's, and Alzheimer's, and genomics.

The models and the mathematical techniques used to solve and study the models have been diverse, from simple discrete models using simple automata algorithms and to highly complex models consisting of coupled systems of nonlinear partial differential equations for which no mathematical theories exist. As a consequence of the latter, numerical computations have been an important tool and will continue to become increasingly important as the complexity of the models increases to account for more and more details.

The Summer Programme will consist of five workshops on the following topics: Cell Biology, Ecology, Epidemiology, Genomics, Physiology. Each of the five workshops in this Special Summer programme will run for approximately two weeks. At the beginning of each two week period, there will be tutorials for one or two days which are designed to help the participants learn more about the topics to be presented in the remainder of the workshop.

Workshop on Genomics, May 31 – June 11, 1999

Organisers: David Sankoff (Centre de Recherches Mathématiques), Michael Waterman (University of Southern California)

Genomics is concerned with the characterization and analysis of genetic material from a wide range of organisms including man. Within the next ten years, the complete genome sequences of human and many other organisms will be determined.

One of the most interesting areas in mathematical biology is modelling evolutionary processes. Bringing theory into the mass of sequence data is one of the most challenging problems we have. The details of modelling triplet repeats (that cause many human diseases) are not yet entirely worked out. Using homologous sequences to infer evolutionary relationships continues to be of great interest, and new simulation techniques are being employed in this area. Sankoff and others have brought into prominence the distance between genomes problems. The most elegant of these is to compute the reversal distance between two gene orders.

Speakers:

- **Nadia El-Mabrouk** (Université de Montréal)
- **Joseph Felsenstein** (University of Washington)
- **Terry Gaasterland** (The Rockefeller University)
- **Philip P. Green** (University of Washington)
- **Tom Hagedorn** (The College of New Jersey)
- **Steven Henikoff** (Fred Hutchinson Cancer Research Center, Seattle, Washington)
- **Susan Holmes** (Stanford University)
- **Leroy Hood** (University of Washington)
- **Richard M. Karp** (University of Washington)
- **John Kececioglu** (The University of Georgia)
- **Gary D. Stormo** (University of Colorado at Boulder)
- **Elisabeth Tillier** (University of Toronto)

Workshop on Mathematical Physiology, June 14–25, 1999

Organisers: Robert Miura (University of British Columbia), Yue-Xian Li (University of

British Columbia), Gerda de Vries (University of Alberta)

This session will be divided into three main topics, neurophysiology, cardiology, and endocrinology.

Neurophysiology is the physiology of the nervous system and is the most quantified branch of the biological and medical sciences. Also, it involves some of the most accurate experimental techniques, e.g., the patch clamp. Neurons and glial cells, including their processes, make up the central and peripheral nervous systems. Neurons are known for their highly complex electrical properties that give rise to a rich variety of dynamical phenomena that have challenged mathematicians for decades. It is also the area where collaborative efforts between experimentalists, mathematicians, and other theorists have had the greatest impact, as evidenced by the pioneering works of Hodgkin and Huxley on the mathematical description of the electrical excitation of the squid giant nerve and of Wilfrid Rall on the electrical properties of dendrites. This session will gather some of the outstanding leaders in this extremely dynamic research field and present a picture of the past, the present, and future of this research field and, most importantly, lay out some of the challenging problems facing us now and in the near future.

Cardiology is the study of the heart and its functions and has become a very active area of research in the medical sciences. A great deal of the electrophysiology and muscle mechanics of the heart is known, and a variety of models have been proposed to increase our understanding of cardiac dynamics. Mathematical modelling, mathematical analysis, and computational methods have helped to reveal the inner workings of the heart, both electrically and mechanically. In this session, we bring together some of the leaders in modelling these phenomena from different points of view.

Endocrinology is the study of gland cells, the secretion of hormones by these cells, and the physiological action of hormones. It is a rapidly expanding field with changing concepts and relatively new to mathematical modellers. Therefore, there is a real need for more collaborative research between experimentalists, modellers, and mathematicians. Hormones are highly potent chemicals that act at low doses and control almost all aspects of our lives including growth, development, metabolism, reproduction, stress response, etc. This session will bring some of the leading researchers in this area together to give an overview of some of their recent research activities.

Speakers:

- **Richard Bertram** (Pennsylvania State University at Erie)
- **Bard Ermentrout** (University of Pittsburgh)
- **Dianne Finegood** (Simon Fraser University)
- **Leon Glass** (McGill University)
- **James P. Keener** (University of Utah)
- **Joel Keizer** (University of California at Davis)
- **John Milton** (University of Chicago)
- **Mark Pernarowski** (Montana State University)
- **Arthur Sherman** (NIDDK/MRB)
- **John Rinzel** (Courant Institute of Mathematical Sciences)
- **Daniel Tranchina** (Courant Institute of Mathematical Sciences)

Workshop on Mathematical Epidemiology, July 19–30

Organisers: Pauline van den Driessche (University of Victoria), Fred Brauer (University of Wisconsin and University of British Columbia)

Mathematical epidemiology is concerned with modelling the spread of infectious disease in a population. The aim is generally to understand the time course of the disease with the goal of controlling its spread. Such models are used, for example, to guide policy in vaccination strategies for childhood diseases. During the last twenty years, models with variable population size have been formulated and analyzed. Such

models combine demographic and epidemic effects. Striving for more realism, more complex models include such detail as time delays, spatial heterogeneity, age structure, two sexes, multigroups, vectors, and stochastic variation. The dynamical systems that result are highly nonlinear and complex.

This session is designed to bring together established and younger mathematicians and statisticians, biologists, and epidemiologists to take up the current challenges of mathematical epidemiology.

- **Linda Allen** (Texas Tech. University)
- **Sally Blower** (University of California at San Francisco)
- **Frank Ball** (Nottingham University)
- **Carlos Castillo-Chavez** (Cornell University)
- **Herbert Hethcote** (University of Iowa)
- **Karl Hadeler** (Universitaet Tuebingen)
- **Valerie Isham** (University College London)

Workshop on Mathematical Ecology, August 2–13, 1999

Organiser: Marc Mangel (University of California)

Mathematical analysis and methods contribute to the study of ecology at a number of different levels.

Individual behavior. A generation ago, the computational complexity associated with predicting individual behaviour made it an enormous task. The development of computational power has made behavioural prediction using stochastic dynamic programming, genetic algorithms and other optimization methods feasible. Furthermore, this is an area where collaboration between experiment and mathematical theory is particularly fruitful because the time scale of individual behavior is conducive to the rapid collection of data. Even so, many mathematical challenges remain, ranging from problems of numerical analysis of interpolation at boundaries to overcoming the curse of dimensionality in problems with many state variables.

Single population dynamics. The analysis of the population dynamics of single species has contributed to the development of nonlinear differential equations, the theory of chaos (through analysis of discrete maps), nonlinear diffusion theory (through analysis of equations such as the Fisher equation), and stochastic population theory. Many interesting problems remain. These include: i) determining the spectra of time series generated by nonlinear maps (a topic that received much coverage in high profile journals such as Nature, recently), ii) connecting nonlinear stochastic and deterministic models where closure problems similar to the ones in the theory of turbulence arise, and iii) the origins of diffusion models from discrete movement models, particularly when some fraction of the population may make large movements.

Multi-species population dynamics and community ecology. The interactions of two or more species, as in predation, competition, mutualism and disease, present new kinds of mathematical challenges. These include the extension of phase plane analysis to more than two dimensions, the estimation of parameters for complicated nonlinear systems, the possibilities of large excursions (as occur in pest or disease outbreaks) and understanding the stability properties of large multidimensional systems of ordinary, partial, and stochastic differential equations.

Speakers:

- **Fred Adler** (University of Utah)
- **Colin Clark** (University of British Columbia)
- **Michael Doebeli** (University of British Columbia)
- **Greg Dwyer** (University of Chicago)
- **Steve Ellner** (North Carolina State University)
- **Shea Gardner** (Imperial College at Silwood Park)
- **Don Ludwig** (University of British Columbia)
- **Bernard Luttbeg** (Yale University)
- **Marc Mangel** (University of California at Santa Cruz)
- **Jonathan Newman** (University of Oxford)

Workshop on Mathematical Cellular Biology, August 16–27, 1999

Organiser: Leah Keshet (University of British Columbia)

The fields of molecular and cellular biology have undergone explosive growth over the last decade, with a wealth of biological detail emerging from high-tech experimental techniques. The life of the cell, down to its smallest components is now the subject of intense scrutiny. We know more about the way that the cell is shaped, controlled, how it moves and divides, how it senses and reacts to its environment, and how it influences other cells, than ever before. The way that cell aggregates work together to produce multicellular structures with their own repertoire of behaviour is also a fascinating and fervent area of research. Many of the speakers in this list have worked productively at the interface of mathematics and biology. Their collective understanding, synergy, and presentation strengths will make this an exciting and informative session. The order of the topics will proceed from the subcellular and gradually go up the hierarchical scale, highlighting some of the most exciting and productive areas of cross-fertilization of mathematical, theoretical and experimental work.

This session will focus on a number of specific topics:

- *Subcellular molecular dynamics and control of cell behaviour.* This topic focuses on the behaviour of molecular systems that lead to periodic behaviour, e.g., in cells and in hormonal systems, bifurcation, or other dynamical results that are closely linked with the function of the cell. Signal transduction and calcium dynamics with their implications for cellular behaviour, as well as cellular and intra- cellular oscillations and feedback will form the main theme.

- *The cellular cytoskeleton.* The role that mathematicians who have studied detailed experimental systems have played in understanding the details of the cell will be highlighted. An example is the detailed demonstration of the involvement of various parts of the structure of the cytoskeleton in key steps of the developmental process of a drosophila embryo.

- *Molecular motors to muscle motion.* The mathematical analysis of molecular motors and the role which such analysis plays in understanding the way that molecular motors work will be described. Experimental biologists have studied muscles for some time, and they now are developing an understanding of how motor aggregates (myosin) arrayed along a one dimensional filament work cooperatively to produce muscle motion.

- *Biotechnology applications of cell biology.* Cellular components can be used in designing artificial skin grafts, and artificial vessels. The understanding of the interactions of cells with their molecular components and extracellular matrix is vital to success in biomedical applications. A particular problem is how the cytoskeleton dynamics affects signal transduction.

- *Cell-surface receptors, the cytoskeleton, and cell division.* Two topics will be discussed. One topic will focus on the way that cells sense their environment and respond to incoming signals. Cell-surface receptors are important and experiments and models for the diffusional and interaction dynamics of such systems have been developed. The second topic is on the problem of cytokinesis, cell-division, and how the cell accomplishes this complex task. Numerical simulations of the dynamics of the cytoskeleton have been carried out.

- *Cell motion and interaction: models and visualization.* The important problem of cell motion from the point of view of many cells, cell aggregates, and interactions of cells with one another and with their environment will be discussed. Models have been developed for cell motion, chemotaxis, and interactions, including immunological networks. New computational techniques,

e.g., immersed boundary methods, can be used to show the motions and and interactions of cells, e.g., in models of biofilms.

Speakers:

- **Dean Bottino** (University of Utah)
- **Micah Dembo** (Boston University)
- **Evan Evans** (University of British Columbia)
- **Victoria Foe** (University of Washington)
- **Byron Goldstein** (Los Alamos National Laboratory)
- **Alex Mogilner** (University of California at Davis)
- **Gary Odell** (University of Washington)
- **Lee Segel** (Weizmann Institute)
- **Carla Wofsy** (University of New Mexico)

3.3 Graph Theory & Combinatorial Optimization, June-August 2000

This is a joint programme of the Fields Institute and the Pacific Institute of Mathematical Sciences for a special year on graph theory and combinatorial optimization, to occur over the period September 1999 to August 2000. The plan is for the activity September through May to take place primarily at Fields and the activity June through August to take place at PIMS. The fall term would concentrate on combinatorial optimization, and the remaining eight months would concentrate on graph theory and related topics.

Organizing Committee: Joseph Cheriyan (University of Waterloo), Derek Corneil (University of Toronto), Bill Cunningham (University of Waterloo), Penny Haxell (University of Waterloo), Mike Molloy (University of Toronto), Bruce Richter (Carleton University), Levent Tunçel (University of Waterloo), Brian Alspach (Simon Fraser University), Richard Anstee (University of British Columbia), Luis Goddyn (Simon Fraser University), Arvind Gupta (Simon Fraser University), Kathy Heinrich (Simon Fraser University), Pavol Hell (Simon Fraser University), David Kirkpatrick (Simon Fraser University), Karen Seyffarth (University of Calgary), Noga Alon (Tel Aviv University), Bill Pulleyblank (IBM Watson Research), Alexander Schrijver (CWI Amsterdam)

Overview: Mathematically, a graph consists only of a set of "vertices" and a set of pairs of vertices that are "joined" by "edges". Physical examples abound. For example, the vertices can be communication centres and the edges can represent direct connections between pairs, or the vertices can be the atoms of a molecule, and the edges can be chemical bonds. Although graphs are extremely basic objects, *Graph Theory,* which the studies the theoretical structure of graphs and the algorithmic exploitation of such structure, is a deep and active part of mathematics. Moreover, there are important applications and strong connections to other parts of mathematics and computer science.

Combinatorial Optimization is the mathematics of finding the best among some collection of discrete structures. An example would be to find the graph with some connectivity property and having the smallest number of edges, or to find the best route through a given graph. Again, this subject is both mathematically interesting and rich with applications.

Programme Summary and Schedule

This proposal is to devote the year 1999–2000 at the Fields Institute and the Pacific Institute of Mathematical Sciences to the study of these two subjects, emphasizing recent results, open problems, applications, and connections with other parts of mathematics and computer science. The main vehicles will be: a series of workshops focusing on particular aspects of these subjects, a series of courses to initiate graduate students and interested workers from related fields into these subjects, and long term visits by postdoctoral fellows and Canadian and international experts.

There will be approximately fourteen workshops: six at the Fields Institute during Fall '99 – May '00, and eight at PIMS during Summer

'00. Below we include a list of tentative topics from which we will choose the topics of most of the workshops. It is possible that one or two workshop topics will come from outside this list, due for example to an exciting new development, or to the presence of a prominent visitor around whose research area we wish to organize an event.

We envision various formats for the workshops, tailored to the topic and the desired objectives. For example, some will be in the style of conferences with many presentations, while some will have few if any lectures and will focus more strongly on collaboration. Many will include some general background lectures to aid the participation of graduate students and others who are new to the field.

Workshop topics:

1. Polyhedral and semidefinite programming methods in combinatorial optimization.
2. Matchings, matroids and extensions.
3. Algebraic representations of graphs and matroids.
4. Approximation algorithms.
5. Graph embeddings and minors.
6. Randomized algorithms.
7. The Probabilistic Method.
8. Structured families of graphs.
9. Extremal graph theory & Ramsey theory.
10. Interconnection networks.
11. Computational geometry and geographical information systems.
12. Partial k-trees.
13. Colourings and homomorphisms.
14. Graph decompositions.

Graduate Courses

A main goal is to involve graduate students in the activities of the programme. The graduate courses planned at PIMS for the summer of 2000 will not be standard courses, but rather more concentrated short courses, usually arranged in conjunction with a workshop.

- **Computational Geometry and Geographical Information Systems**
  This is a short course in CG and GIS for graduate students and industry. The idea is to provide students and industry participants with a survey of CG and GIS, of their interactions and possibilities. This will allow them to learn more from this specialist conference. We envision a length of 2.5 days and will have it precede the workshop on this subject.

  Format: introductory lectures in CG and GIS with advanced topics sessions in geometric primitives and data structures, experimental study of algorithms, theory and practice of data conversion, robust geometric computation, evaluation of spatial search structures, compression of GIS data. Hands-on experiments in the computer lab will reinforce selected topics. Open problems.

  Possible short course leaders: Jack Snoeyink (UBC), Jörg-Rüdiger Sack (Carleton), Christopher Gold (Laval), Marc van Kreveld, Andrew Frank (TU Wien), Michael Goodchild (UC Santa Barbara), Christopher Jones (U Glamorgan).

  Possible participation by selected industry speakers: Pam Soloway (PAMap), Dan Lemkow (EPS), Scot Morehouse (ESRI) or others.

- **Partial k-trees**
  Below is the outline for a one-week summer school emphasizing the recent results on partial k-trees.
  Day 1: Introduction; role in the graph minors theorem; historical perspective; defini-

tions of k-trees; related graph classes; tree-decompositions; applications; recognition.
Day 2: Logical formulations of properties and dynamic programming; Monadic Second Order Logics and its variants; tree-automata; recognizability versus definability.
Day 3: Algorithms for properties not expressible in the logic; pumping lemmas.
Day 4: Bounded parameterized classes.
Day 5: Open problems and new directions.

- **Graph Decompositions**
  We envisage that the two weeks of various invited speakers in the workshop on this subject will be carefully chosen so as to provide a coordinated graduate course in the area. Such a course could not normally be given.

Workshop Descriptions

In what follows, we elaborate on the workshop topics to be held at PIMS and in some cases provide greater detail towards some of the anticipated activities. We also list potential organizers, and potential participants both from Canadian universities and from outside of Canada. These lists are meant only to give some idea of the possible interested participants but is unlikely to be a complete list.

Although we are only listing the PIMS workshops in detail, we anticipate substantial cooperation with Fields during this year in Graph Theory and Combinatorial Optimization.

Interconnection Networks

Organizer: N. Pippenger (U.B.C.)

The theory of interconnection networks applies graph theory and other areas of discrete mathematics to communication problems. The area of telecommunications in general, and communication switching in particular, is one in which Canada has made prominent contributions to world-wide development. It is also one undergoing rapid change in response to the the widespread demand created by personal computers and the World-Wide Web. The theory of interconnection networks has also found application to computers themselves, both because the communication problems solved by interconnection networks arise in parallel and distributed computers, and because some computational problems have at their heart subproblems that are essentially communication problems.

The theory of interconnection networks uses graphs as models of networks, both in the small, where a vertex might represent a wire and an edge might represent a switching element, and in the large, where a vertex might represent a metropolitan switching centre and an edge might represent a collection of communication channels.

Such models are used in the analysis of situations such as message or packet switching, where bundles of information move from vertex to vertex in a graph, and circuit switching, where dedicated routes between information sources to information sinks may be set up and taken down.

Finally, it should be mentioned that some studies of interconnection networks are purely combinatorial, as for example when satisfactory performance in the worst case is required, while others involve probabilistic modelling of traffic and average case analysis of performance is appropriate.

This workshop will address all of the aspects of interconnection networks mentioned above, with emphasis governed by the trends and opportunities present at the time. The workshop will last two week. Six to eight speakers will present surveys of various aspects, while others will be selected to present specific recent research results. It is hoped that this combination will facilitate the entry of new researchers to the field, as well as provide for the exchange of information among researchers with an established interest.

Potential Participants: J. Friedman (UBC), A. Liestman (SFU), J. Peters (SFU) A. Borodin (UT), E. Elmallah, F. Fich (UT), P. Haxell (UW), F. Chung (USA), G. Masson (USA), D. Sotteau (France), E. Upfal

Computational Geometry and Geographical Information Systems

Organizer: J. Snoeyink (U.B.C.)
Computational geometry started as an indepen-

dent research discipline about 20 years ago. Research relevant to computational geometry involves the study of the computational complexity of well defined problems that have geometric constraints as well as the design, analysis and implementation of algorithms and associated data structures for the efficient solution of these problems. Thus, computational geometry concerns the study of familiar problems in combinatorics and discrete mathematics with added geometric constraints, the application of tools from discrete mathematics in the formulation and analysis of geometric algorithms, and the application of these algorithms in the widespread application domains that naturally give rise to problems with geometric attributes or constraints. Fundamental application areas identified in the recent reports setting out strategic directions for the development of the discipline [Chazelle, Tamassia] include computer graphics and imaging, shape reconstruction, computer vision, geographic information systems, mesh generations, robotics, robustness, molecular biology, and information visualization, which includes among others graph drawing and algorithm animation.

Computational geometry has established itself both as a discipline and as a community of researchers. It enjoys two unique assets:

(a) its diversity and potential to affect most forms of computing;

(b) its mature algorithmic foundations.

To realize the discipline's full potential for usefulness to others and to maintain its vigor, the community now seeks close collaboration with theoreticians in other areas such as graph theory, combinatorics, and discrete optimization, and practitioners in relevant application areas. Our proposal for computational geometry based activities within this special year touch on both of these forms of "outreach".

The conference in Computational Geometry and Geographic Information Systems will last 2.5 days. We will invite international specialists in particular facets of the interaction between geometric computation in CG and in GIS to participate in a conference with specialists from local academia and industry. Graduate students from Canadian institutions will be able to take part.

Potential Participants: Bhattacharya (SFU), Fournier (UBC), Kirkpatrick (UBC), Shermer (SFU) Sack (Carleton), Gold (Laval), Toussaint (McGill), B. Chazelle (USA), H. Edelsbrunner (USA), F. Preparata (USA), R. Seidel (Germany).

Partial k-trees

Organizer: A. Gupta (SFU)

The class of partial k-trees merits investigation due to its increasing importance in algorithmic graph theory; it plays multiple roles, by serving as a bridge between well-understood graph classes and those for which fewer results have been obtained. One subject of study is the phenomenon that there are linear-time algorithms on partial k-trees for almost all interesting graph properties. This line of research was first considered in a 1984 paper by Bern, Lawler, and Wong; today researchers work to delineate a general theory and characterization of properties for which fast algorithms are possible. Since the class of partial k-trees encompasses graph families such as forests, series-parallel graphs, outerplanar graphs and Halin graphs, algorithms for partial k-trees imply immediate results on such graphs.

Further interest in partial k-trees stems from their role in the seminal work of Robertson and Seymour on graph minors. Here, partial k-trees were used as a base case in a proof by structural induction. The representation of a graph as a labelled tree-like structure, known as a tree decomposition, is of interest in its own right; partial k-trees are those graphs which can be represented with a bound on the size of the label of a vertex, hence the name graphs of bounded tree-width. Viewed in this way, an understanding of partial k-trees may lead to ways of solving problems on more general classes of graphs.

Recent interest in this area has resulted in even more interesting open questions concerning partial k-trees, three of which are outlined below.

1. It is known that any property expressible in a certain logical framework can be con-

verted into a tree-automaton, thus yielding a linear-time algorithm on partial k-trees. It is not known whether or not all tree-automata can be converted into properties expressible in the framework.

2. In recent work, a number of linear-time properties on partial k-trees have been developed which do not seem expressible within the logical framework. This naturally leads to the question of whether and how the framework needs to be extended to yield a complete characterization of the properties.

3. The work of Robertson and Seymour implies (non-constructively) that for each k there is a finite characterization of partial k-trees in terms of minimal excluded graphs under the minor ordering. However, to date characterizations are only known for $k \leq 3$.

The workshop will convene experts in the area to discuss the fundamental open questions outlined above, as well as other related problems. As Canadians have taken a leading role in the development of this theory, holding the event in Canada will help to establish and strengthen collaborations, train graduate students in the area, and highlight Canadian research on partial k-trees.

Potential Participants:

Fellows (UVic), Goddyn (SFU), Hell (SFU), King (UVic), Peters (SFU), Shermer (SFU), Stewart (Alberta), Corneil (UT), Kaller (Langara), Nishamura (UW), Ragde (UW), Arnborg (Sweden), Bodlaender (Netherlands), Courcelle (France), Proskurowski (USA), Robertson (USA), Seymour (USA), Thomas (USA).

Graph Colourings

Organizer: P. Hell (SFU)

Graph colourings are at the core of graph theory. Starting from the infamous four colour conjecture, now theorem, all the way to applications in scheduling, graph theory developed along with the study of colourings. From both theoretical and algorithmic perspective, colourings have always played a central role.

Nowhere-zero flows were introduced by Tutte as an extension of chromatic number. Indeed a flow is the matroidal dual of a graph colouring. Many well known graph colouring problems, such as the Four Colour Theorem, extend naturally to problems about flows. There are several outstanding problems about flows, such as Tutte's conjecture that every graph has flow number at most five. Circuit covers were introduced in 1979 when Seymour proposed the still-unsolved Circuit Double Cover Conjecture. This conjecture is closely related to the topic of Surface Embeddings of graphs. Relating these three areas together will be the focus of part of this workshop.

Recently, the theory of colourings has benefited from an introduction of algebraic techniques, through the vehicle of list homomorphisms. At the same time, generalizations of colourings, especially graph homomorphisms, have also enjoyed much popularity. List homomorphisms, like list colourings, exhibit certain properties that can be exploited in the design of efficient algorithms. Both list colourings and list homomorphisms owe a historical debt to constraint satisfaction problems (which in fact are more general than both these concepts), studied in artificial intelligence. In fact some of the AI techniques have only recently been rediscovered by graph theorists. Finally, any of these concepts lead naturally to practical applications in timetabling and scheduling.

The workshop will invite experts as speakers and will provide both expository lectures as well as lectures on recent results. There will be ample time for discussions and only limited time for contributed talks. A very positive contribution will be bringing research communities together. For example, by bringing together people interested in constraint satisfaction problems with the graph colouring people important cross fertilization will occur. Graduate students should find the environment very stimulating.

Potential Participants: D. Corneil (UT), M. Fellows (UVic), L. Goddyn (SFU), G. Hahn (UdeM), W. Havens (SFU), J. Huang (UVic), G. MacGillivray (UVic), C. Godsil (UW), A. Mackworth (UBC), D. Miller (UVic), M. Molloy (UT), R. Nowakowski (Dal), B. Richter (Car-

leton), I. Rival (UO), G. Sabidussi (UM), N. Sauer (UC), K. Seyffarth (UC), C. Tardif (UM), D, Younger (UW), M. Albertson (USA), N. Alon (Israel), J. Bang-Jensen (Denmark), J-C. Bermond (France), R. Dechter (USA), T. Feder (USA), E. Freuder (USA), B. Gerards (Holland), A. Galluccio (Italy), W. Imrich (Austria), J. Kratochvil (Czech R), L. Lovasz (USA), J. Nesetril (Czech R), M. Perles (Israel), V. Rodl (USA), B. Reed (France), P. Seymour (USA), E. Sopena (France), M. Tarsi (Israel), C. Thomassen (Denmark), X. Zhu (Taiwan).

Graph Decompositions

Organizer: B. Alspach (S.F.U.)

Graph decompositions is a topic at the heart of graph theory. Decomposition problems have a long history, have spawned large areas of research, and continue to be studied by many people inside and outside of graph theory. Steiner triple systems were introduced early in the nineteenth century. When viewed as decompositions of complete graphs into complete graphs of order 3, their generalization leads to the well studied field of design theory. When viewed as decompositions of complete graphs into 3-cycles, their generalization leads to a wide range of problems dealing with decomposition of complete graphs into cycles.

Vertex coloring is a topic that was introduced in the middle of the nineteenth century, has generated considerable research over the years and has important scheduling applications. It corresponds to a particular kind of vertex decomposition of a graph. Edge coloring problems also have scheduling applications and have been studied extensively. They correspond to decompositions of graphs into 1-factors.

The preceding topics are still actively studied along with many new areas of investigation. G. Ringel's conjecture that K_{2n+1} can be decomposed into any fixed tree of size n directly led to the notion of a graceful labelling of a tree. That in turn spawned the very active area of graph labellings. The cycle double cover conjecture has attracted a lot of attention over the last twenty years. Isomorphic factorizations, orthogonal factorizations and ascending subgraph decompositions are other areas in which there are many unsolved problems and considerable research activity.

This workshop will address edge decomposition problems. The workshop will last two weeks. Approximately eight speakers will be chosen to present the background material, techniques and current directions for a particular topic. Each day there will be 2-3 hours of lectures. The two weeks will comprise an excellent graduate course for students and credit can be arranged. The workshop is a unique opportunity to create such a course.

Potential Participants: Anstee (UBC), Goddyn (SFU), Heinrich (SFU), Verral (SFU), Yu (Cariboo), Yu (Fraser Valley), Hartnell (St. Mary's), Rosa (McMaster), Anderson (Denmark), Bryant (Australia), Rodger (USA), Wallis (USA), Zhang (USA).

3.4 Summer School and Workshop in Algebra and Related Areas

University of Alberta
June 19 – July 14, 2000

Local Organizers: Bruce Allison, Gerald Cliff, Robert Moody, Arturo Pianzola, Akbar Rhemtulla, M. Schlottman, Mazi Shirvani, Alfred Weiss.

The Summer School/Workshop will concentrate on 3 areas: groups and their representations, Lie theory, and the mathematics of aperiodic order. As its name suggests, the plan is to incorporate both an instructional and research components in each of the three broad areas.

Each area will be featured for a 2 week period and will have lecturers of international stature. The first week will be devoted to a series of introductory lectures, aimed at giving the students an introduction to the subject in question. The second week will be the workshop/conference which will be run at a research level and will welcome additional researchers and students who wish to participate. The programme is staggered (see below).

The School will be open to graduate students,

recent Ph.D.'s, and advanced honours students. Financial support will be available to support selected participants. Students will be expected to participate in the teaching part of each of the three areas.

The activities of the three concentration areas will be staggered according to the following schedule.

June 19–23: Lie School

June 26–30: Lie Workshop, Groups School

July 3–7: Groups Workshop, Aperiodic School

July 10–14: Aperiodic Workshop

Main speakers will stay for the full 2 weeks of activity of their area and will be fully supported for travel and local expenses.

On each of the 3 internal weekends, we plan to have a trip to Jasper. We plan to have accommodation there that will allow the groups to continue to have scientific interactions.

Lie Theory Component

Canada has a strong representation in the algebraic side of Lie theory. The proposed meeting is to make sure that Canada's visibility in the international Lie theory community is maintained.

The timing of this event is particularly favorable because of the during the fall of 2000 there will be a semester at the Fields Institute on infinite dimensional Lie theory. It is our intention to use the minicourses of this conference to prepare the students for the Fields' activities.

The main lecturers will be:

- **Geogia Benkart** (Madison): "Infinite dimensional Lie theory"
- **Stephen Donkin** (QMW London): "Algebraic groups"

In addition the following have shown definite interest in attending: Victor Ginzburg (Chicago), Victor Kac (MIT), Karl Neeb (Erlangen).

Potential Canadian Participants include: Jim Carrell, Keqin Liu and Dale Peterson (UBC), Bruce Allison, Gerald Cliff, Terry Gannon, Robert Moody, and Arturo Pianzola (Alberta), Stephen Berman (Saskatchewan), John Coleman, David Pollack and James Shank (Queens), David Wehlau (Royal Military College, Kingston), rober Beddard (UQUAM), D. Djokovic (Waterloo), Erhard Neher, Michel Racine, and Wult Rossman (Ottawa), Nautel Bergeron and Yun Gao (York), Abraham Broer, Yvan Saint-Aubin (Montreal), Chris Cummings (Concordia), John Labute (McGill), Yuly Billig (New Bruswick).

Group Theory Component

Groups play a central role in just about all the branches of mathematics and continue to be a very active area of research as evidenced by the recent Field Medals awarded in the area.

At present we have the culmination of a three directional attack on the Burnside problems. The first consists of the geometric methods of Ol'Shanskii in producing finitely generated groups of finite exponent that are infinite (a vast improvement of Adian's construction which is one of the technically most difficult piece of work of over 300 pages!). The second is the positive solution of the restricted Burnside Problem for residually finite groups by Zelmanov, and the third is the p-adic analytic methods in dealing with questions of linearity of residually finite groups by Alex Lubotzky and Avinoam Mann. There are also the remarkable advances made by Aner Shalev, Lubotzky, and others on pro-finite groups and results of Dan Segal and others for residually finite solvable groups.

Representation theory continues of fundamental importance in mathematics and other sciences. There has been much recent progress, especially, on the representation theory of finite groups of Lie type, which ties together the Lie theory and group theory themes of the programme. Modular representation theory is also an area of considerable activity.

The conference will present an excellent opportunity to get a broad picture of these manifold activities as told by the masters themselves to our graduate students and fresh Ph. D's. We wish to stress that the all main talks will be of the "colloquium" nature, reserving specialized talks for the afternoon sessions meant for the experts.

Instructional lectures will be given by:

- **Michel Broué** (University of Paris VII): "Representations of Groups of Lie Type"
- **Peter Kropholler** (Queen Mary College, London): "Cohomological Methods"
- **Dan Segal** (Oxford University): "Residually Finite Groups"
- **Aner Shalev** (Hebrew University, Jerusalem): "Profinite and p-adic Analytic Groups"

In addition the following people have agreed to attend: A. Lubotsky (Hebrew Univ. Jerusalem), A. Yu. Ol'shanksii (Moscow State U.), Don Passman (Wisconsin), Geoffrey Robinson (University of Birmingham), Alexandre Turull (University of Florida), Robert Guralnick (University of Southern California), and Roderick Gow (University College, Dublin). In addition E. Zelmanov (Yale) has shown interest in attending. if his schedule permits.

Aperiodic Component

The course aims to provide the students with the background to understand the main ideas being used at present in the development of the mathematics of aperiodic order. One of the appealing aspects of this subject is the way in which it draws together a number of diverse subdisciplines of mathematics: discrete geometry, algebra, analysis, and measure theory and topological dynamics. For this reason the instructional part will be given by three or four speakers. It is our intention to give the students a reasonable feel for main ideas and to provide sufficient background and lots of pointers so that they may pursue it more deeply later on. All the speakers have agreed to be here for the full two weeks.

The conference/workshop part of the programme, which will occur in the second week, will focus on the most recent developments. We plan still to keep the pedagogical spirit and it is hoped that a number of the more interested students will stay on. We have already seen considerable interest in this event by other research workers in the mathematical and physical aspects of aperiodic order, and will have no trouble in making this into a very productive research oriented meeting.

Principal Speakers

- **Jeff Lagarias** (AT & T Research Labs)
- **Boris Solomyak** (Mathematics, Washington State U., Seattle)
- **Michael Baake** (Theoretical Physics, U. Tübingen, Germany)
- **Andrew Vince** (Mathematics, Florida State Univ.), not yet completely confirmed

The areas of the courses are:

(a) aperiodic sets from a geometric and algebraic points of view

(b) aperiodic sets from the dynamical systems point of view

(c) measures and diffraction

For the second week, the following additional speakers have been invited:

- **M. Schlottmann** (Tübingen)
- **J. P. Gazeau** (Paris VII)
- **Petra Gumelt** (Griesfald)

There will also be a number of additional speakers from from North America.

Chapter 4

General Scientific Events for 1998–99

Due to its unique structure, PIMS is able to move quickly to produce and promote the latest advances in the mathematical sciences and involve PIMS' scientists in them. Rather than centering all its scientific activities around a few topics for an entire academic year, thus tying up resources and limiting participation, PIMS also runs shorter, more intensive programmes to emphasize rapidly developing areas. The flexibility of this structure improves communication between PIMS' members and the larger scientific community, resulting in better trained personnel and establishing vigourous dialogue between the mathematical sciences and the other disciplines.

4.1 PIMS Lecture Series

PIMS Distinguished Colloquium Series

Organizer: D. Rolfsen (UBC)

PIMS started a distinguished colloquium series in 1996 featuring scientists from industry and academia. The lectures are often delivered from one of the PIMS sites while video links are provided to the others and at times to UNBC and to the University of Lethbridge. Recent lectures are:

April 6, 98: **Avi Wigderson**, Hebrew University of Jerusalem.
Title: "A Computational View of Randomness"

April 23, 98: **Beno Eckmann**, ETH Zurich.
Title: "Four-manifolds and group invariants".

September 10, 98: **Mitchell Luskin**, University of Minnesota.
Title: "Modelling, analysis and computation of crystalline microstructures".

October 29, 98: **Nicole Tomczak-Jaegermann**, University of Alberta.
Title: "Asymptotic Aspects in Geometric Functional Analysis".

January 21, 99: **Gilbert Strang**, M.I.T.
Title: "Cosine Transforms and Wavelet Transforms and Signal Processing".

May 13, 99: **Richard Karp**, U. of Washington.
Title: "The Design of Molecular Bar Codes: A Combinatorial Problem from Molecular Biology".

4.2 1999 Mini-Programmes

Geometric Functional Analysis, PIMS, UBC, June 27 - July 18, 1999

Organizers: Vitali Milman (Tel Aviv), Nicole Tomczak-Jaegermann (University of Alberta).

Geometric Functional Analysis is concerned with geometric and linear properties of finite- and infinite-dimensional convex bodies. General framework and deep geometric, probabilistic and combinatorial methods developed here are used in many areas outside the field, in Analysis, Geometry and many others.

Over the recent years, Geometric Functional Analysis noted several significant accomplish-

ments. Marked by two Fields Medals by J. Bourgain, 1994 and T. Gowers, 1998; the Plenary Address at the European Congress of Mathematics, 1996 by V. Milman, and two Plenary Addresses at the International Congress of Mathematicians, 1998, by G. Pisier and M. Talagrand. Also, 4 invited lectures at the last two Congresses (Gowers, Odell-Schlumprecht, Milman, Tomczak) represented the spectrum of achievements from geometric purely infinite dimensional phenomena to high dimentional ones.

The present Workshop will concentrate on asymptotic theory of finite-dimensional normed spaces and related topics of convexity, probability theory, isoperimetric inequalities, random matrices and others. Also, new connections with the theory of infinite-dimensional Banach spaces, and its recently developed asymptotic aspects, will be touched.

This Workshop will bring the top researchers in the field together to exchange new ideas and present their recent results. Young researchers, postdocs and advanced Ph.D. students are also encouraged to attend. An emphasis will be placed on encouraging interactions between young researchers and the senior mathematicians attending the meeting.

Workshop Participants Include: **Dan Amir** (Tel Aviv University), **George Androulakis** (Texas A&M University), **Spiros Argyros** (University of Athens), **Wojciech Banaszczyk** (University of Lodz), **Franck Barthe** (Universite de Marne-la-Vallee), **Sergey G. Bobkov** (Syktyvkar University), **Apostolos Giannopoulos** (University of Crete), **Efim D. Gluskin** (Tel Aviv University), **Yehoram Gordon** (Technion), **W. Timothy Gowers** (Cambridge University), **Olivier Guedon** (University of Paris VI), **Petr Hajek** (Texas A&M University), **William B. Johnson** (Texas A&M University), **Nigel Kalton** (University of Missouri), **Hermann Koenig** (Universitaet Kiel), **Alex Koldobsky** (University of Texas at San Antonio), **Rafal Latala** (Warsaw University), **Joram Lindenstrauss** (Hebrew University), **Alexander Litvak** (Univ of Alberta), **Piotr Mankiewicz** (Polish Academy of Sciences), **Mathieu Meyer** (Universite de Marne-la-Vallee), **Edward Odell** (University of Texas at Austin), **Krzysztof Oleszkiewicz** (Warsaw University), **Alain Pajor** (Universite de Marne-la-Vallee), **Gilles Pisier** (University of Paris VI), **Aleksander Pelczynski** (Polish Academy of Sciences), **Shlomo Reisner** (Haifa University), **Haskell P. Rosenthal** (University of Texas at Austin), **Mark Rudelson** (University of Missouri), **Gideon Schechtman** (Weizmann Institute of Sciences), **Thomas Schlumprecht** (Texas A&M University), **Carsten Schuett** (Universitaet Kiel) **Stanislaw Szarek** (University of Paris VI), **Michel Talagrand** (Ohio State University), **Tony Tsolomitis** (University of Crete), **Elisabeth Werner** (Case Western Reserve University).

Conference in Convex Geometric Analysis June 30 – July 3, 1999, PIMS, UBC

Scientific Committee of the Conference: Jean Bourgain, Timothy Gowers, Michail Gromov, Gilles Pisier, Nicole Tomczak-Jaegermann

The mini-programme in Geometric Functional Analysis will also incorporate a satellite conference in honour of Vitali Milman's 60^{th} birthday. Closely related to the workshop, this conference will have a broader scientific content. The participants of the workshop are of course warmly invited to attend, and we also expect additional speakers. The format will be that of a typical conference, with several talks per day. Both the scientific programme and the associated social activities will celebrate Vitali's 60's Birthday.

Frontiers in Mathematical Physics Workshop on Particles, Fields, and Strings, UBC, Aug. 2-20, 1999

Organizers: Taejin Lee (Kangwon National University), Yuri Makeenko (ITEP, Moscow & NBI, Copenhagen), John Ng (TRIUMF, Vancouver), Soonkeon Nam (APCTP, Seoul), Chaiho Rim (APCTP, Seoul), Alexander Rutherford (PIMS), Gordon Semenoff (UBC, Vancouver), K.S. Viswanathan (SFU, Burnaby), Ariel Zhitnitsky (UBC, Vancouver).

The Centre de Recherches Mathématiques, the Pacific Insitute for the Mathematical Sciences and the Asia Pacific Center for Theoretical

Physics are sponsoring this event. This mini-programme is devoted to modern developments in mathematical physics, gauge and string theories. Topics to be featured in the plenary lectures include non-perturbative string and superstring theory, Anti-de-Sitter space and Conformal field theory, large-N QCD, confining strings, MQCD and duality, and M(atrix) theory. There will be a limited number of lectures per day to allow participants to engage in informal seminars and discussions. Access to computer and library facilities will be provided to participants.

Invited Speakers: **R. Dijkgraaf** (Amsterdam), **D. Gross** (Santa Barbara), **J. Harvey** (Chicago), **P. Horava** (Caltech), **R. Kallosh** (Stanford), **H. Kawai** (KEK), **I. Klebanov** (Princeton) **J. Polchinski** (Santa Barbara), **A. Tseytlin** (Imperial College), **H. Verlinde** (Princeton), **Juan Maldacena** (Harvard), **A. Polyakov** (Princeton)

Participants Include: Paul Percy (Princeton), Alex G. Quiroz Buelvas (D. F. T. — Trieste University), Per Kraus (University of Chicago), David Fairlie (University of Durham, England), Andrei Zelnikov (Department of Physics, Univ. of Alberta), Manu Paranjape (Université de Montréal), Paulo Vargas Moniz (Physics Department, Universidade da Beira), Richard Szabo (The Niels Bohr Institut), Anastasia Volovich (Harvard University), Radu Tatar (Department of Physics, Brown University), Anastasios Petkou (University of Thessaloniki, Greece), Alessandro D'Adda (INFN, Torino), Diego Navarro (Instituto de Fisica Corpuscular, Valencia University), Kyungho Oh (Institution University of Missouri), Gordon Chan (University of California at Los Angeles), Giuseppe Carlino (Dept. of Physics, University of Genova), Romuald Janik (Service de Physique Theorique, CEA Saclay), Sreedhar Vinnakota (Dublin Institute for Advanced Studies), Robert Brandenberger (Physics Dept., UBC), Richard Mackenzie (Physics Dept., UBC), Ivo Klemes (Dept. of Math. and Stats., McGill Univ.), Dongsu Bak (University of Seoul), Taejin Lee (Kangwon National University), Hyunsoo Min (University of Seoul), Soonkeon Nam (APCTP/Kyunghee University), Soo-Jong Rey (Seoul National University), Sang-Jin Sin (Hanyang University)

4.3 Extra-Thematic Scientific Workshops in 1998

This section describes the extra-thematic scientific activities of the institute. Each workshop has its own organizing committee and they are mostly held in the various PIMS sites. The selection and funding decisions are made by the Scientific Review Panel.

The 1998 Canadian Operator Theory and Operator Algebras Symposium, U. Alberta, Edmonton, May 21–26, 1998

Organisers: Anthony T.M. Lau and Laurent Marcoux (U. Alberta).

Organized by Anthony Lau and Laurent Marcoux, this symposium was jointly sponsored by PIMS and the Fields Institute, with additional support from the University of Alberta. It was well attended by participants from 13 different countries, representing 3 continents. The success of this symposium is testament to the vitality of the the Operator Theory/Algebras community in Canada.

Invited speakers: **R, Curto** (University of Iowa), **Ken Davidson** (University of Waterloo), **George Elliott** (Universities of Copenhagen and Toronto), **Don Hadwin** (University of New Hampshire), **David Handelman** (University of Ottawa) **Eberhard Kaniuth**, (Universität Paderborn), **David Larson** (Texas A & M University), **Vitali Milman** (Tel Aviv University), **Vern Paulsen** (University of Houston), **Gert K. Pedersen** (University of Copenhagen), **Zhong-Jin Ruan** (University of Illinois at Urbana-Champagne), **Roger R. Smith** (Texas A & M University)

In addition, there were also 29 contributed talks.

Annual meeting of CAMS and Canadian Symposium on Fluid Dynamics, SFU Harbour center, May 28–31, 1998

Organisers: Dr.Cecil Graham, Simon Fraser University, Dr.Serpil Kocabiyik, University of Manitoba, Ms. Penelope Southby Simon Fraser University

The 19th annual meeting of the Canadian Applied and Industrial Mathematics Society was held simultaneously with the 13th Canadian Symposium on Fluid Dynamics (CSFD) at Simon Fraser University at Harbour Centre in Vancouver, British Columbia, Thursday-Sunday, May 28-31,1998.

In addition to invited and contributed lectures there were mini symposia and workshops organized in collaboration with the Center for Nonlinear Studies at Los Alamos; the Institute for Electrical and Electronics Engineers Incorporated; and the Society for Industrial and Applied Mathematics.

Other highlights included the annual CAIMS/SCMAI doctoral dissertation award lecture; a poster session with a prize for the best graduate student poster; commercial displays, reception, banquet, and more.

The joint conference marked the 74th birthday of Professor Stan Dennis from the University of Western Ontario. Professor Dennis' main research interest is influid mechanics and he has published a large number of articles in the major journals and conference proceedings dealing with this subject. He has served on numerous international committees concerned with research in fluid mechanics and other topics in Applied Mathematics and has been awarded many senior fellowships for research and collaboration by such agencies as the Royal Society of London, NRC (Canada), NSERC (Canada), CNRS (France), SERC (United Kingdom), CERN (Geneva) and NATO.

Invited speakers

- **Michael M. Carroll**, Rice University, "Exact solutions in compressible finite elasticity"
- **M. Coutanceau**, Universite de Poitiers, "Visualization as an aid in pointing out typical fundamentals in flow behaviour"
- **W.O. Criminale**, University of Washington, "Equilibrium and stability in fluid motion"
- **Stan Dennis**, University of Western Ontario, "On the determination of the circulation in two-dimensional flows"
- **J.J. Gottlieb**, University of Toronto, "Some computational problems with dusty-gas flows"
- **Benqi Guo**, University of Manitoba, "Approximation theory, algorithm, and application of the high-order finite element method"
- **W.G. Habashi**, Concordia University, "The impact of 3-D CFD on aircraft in-flight icing simulation"
- **Grafton Hui**, Hong Kong University of Science and Technology, "A unified coordinate system for computational fluid dynamics"
- **D.B. Ingham**, University of Leeds, "The solution of some improperly posed problems in fluid dynamics"
- **C. Jones**, Brown University, "Lagrangian transport in mesoscale ocean structures"
- **S.K. Malik**, FNA, Panjab University, "Instabilities, pattern-formation and chaos in magnetic fluids"
- **Xanthippi Markenscoff**, University of California at San Diego, "Cosserat spectrum theory and applications to solid and fluid mechanics"
- **T.B. Moodie**, University of Alberta, "Gravity driven fluid flows"
- **L. Quartapelle**, Politecnico di Milano, "Solution of the Navier-Stokes equations by an incremental projection methods"
- **Norman Riley**, University of East Anglia, "The Czochralski crystal-growth system"
- **A.J.M. Spencer**, University of Nottingham, "The thermoelastic springback problem and related phenomena"
- **Patrick D. Weidman**, University of Colorado, "Similarity reductions in fluid dynamics"

Pacific Rim Geometry Conference, UBC, Vancouver, June 28 – July 2, 1998

Organisers: D. Austin (UBC), J. B. Carrell (UBC), Peter Li (UCI), S.-T. Yau (Harvard).

The Pacific Rim Geometry Conference was created in the early 1990's as a major international conference designed to bring together geometers from Pacific Rim countries. While representing the full breadth of geometry, its purpose

is to disseminate the most recent research developments and to cultivate working relationships among its participants. As previous Conferences have been held in Hong Kong, Singapore and Seoul, this is the first time the Conference has come to North America.

Invited speakers:

J. Chen (Vancouver), "Reduction from instantons to holomorphic curves"

S. Donaldson (Stanford, Oxford),

K. Fukaya (Kyoto), "Geometric, homological, categorical and noncommutative mirror symmetries"

W. Fulton (Chicago), "Quantum Schubert Calculus"

A. Givental (Berkeley), "Quantum K-theory and Quantum Groups"

J.-M. Hwang (Seoul), "Holomorphic maps from G/P onto projective manifolds"

J. Li (Stanford), "Topological method in moduli problems in algebraic geometry"

P. Li (Irvine), "Convexity properties of harmonic maps"

K. Liu, "Mirror Principle "

C. Taubes (Harvard), "Self-dual 2-forms and their pseudo-holomorphic curves"

G. Tian (MIT), "Gauge theory and calibrated geometry"

R. Schoen (Stanford), "The structure of Lagrangian submanifolds which are extremal for volume"

K. Uhlenbeck (Texas), "Space-time monopoles and the Bianchi Permutability Formula"

Participants: Dave Auckly (Kansas State University), David Austin (University of British Columbia), Adrian Butscher (Stanford University), James Carrell (University of British Columbia), Jingyi Chen (University of British Columbia), Roger Chen (National Cheng Kung University), Leung-Fu Cheung (Hong Kong Polytechnic University), Oliver Collin (University of British Columbia), Andrew Dancer (McMaster University), Yi Fang (Australian National University), Frank Flaherty (Oregon State University), Dan Fox (University of Wa shington), Ailana Fraser (Stanford University), Richard Froese (University of British Columbia), Kenji Fukaya (Kyoto University), William Fulton (University of Chicago, University of Michigan), Peter Gilkey (University of Oregon), Alexander Givental (University of California, Berkeley), Mark Goresky (Institute for Advanced Study), Weiqing Gu (Harvey Mudd College), Marshall Hampton (University of Washington), Zheng-Chao Han (Rutgers University), Steven Harris (Saint-Louis University), Andrew D. Hwang (University of Toronto), Jun-Muk Hwang (Seoul National University), Marcos B. Jardim (Stanford University, University of Oxford), Sadok Kallel (University of British Columbia), Spiro Karigiannis (Harvard University), Michael Kozdron (University of British Columbia, Duke University), John V. Leahy (University of Oregon), John M. Lee (University of Washington), Yng-Ing Lee (Taiwan University), Man-Chun Leung (National University of Singapore), Jun Li (Sanford University), Peter Li (University of California, Irvine), Bong Lian (Brandeis University), John Loftin (Harvard University), Robert MacPherson (Institute for Advanced Study), David McMath (Stanford University), Gouwu Meng (Hong Kong University of Science and Technology), Chikako Mese (University of Southern California), Peter Milley (University of British Columbia), Helen Moore (Bowdoin College, Stanford University), Alexander Nabutovsky (University of Toronto), Lei Ni (University of California, Irvine), Liviu I. Nicolaescu (McMaster University), Anne O'Halloran (University of British Columbia), Maxim Pavlov (City University of Hong Kong), Jesse Ratzkin (University of Washington), Regina Rotman (Courant Institute of Mathematical Sciences), Nikolai Saveliev (University of Michigan), Jean-Marc Schlenker (Universite de Paris-Sud), Richard Schoen (Stanford University), Jan Segent (University of Missouri), Soret (Universite de Tours), Ahmad El Soufi (Universite de Tours), John M. Sullivan (University of Illinois), C.J. Sung (National Chung Cheng University), Luen-Fai Tam (Chinese University of Hong Kong), Cliff Taubes (Harvard University), Andrejs Treibergs (University of Utah), Karen Uhlenbeck (University of Texas), Norm Vestrup, Yau Heng Tom Wan (Chinese University of Hong Kong), Jiaping Wang (Cornell University), McKenzie Y. Wang (McMaster University), Sumio Yamada (Massachusetts Institute of Technology), David Y. Yeung (University of British Columbia), Jedrzej Sniatycki (University of Calgary)

Workshop on Micro-structural Models of Fracture Processes, UBC, August 10–12, 1998

Organiser: Anthony Peirce, UBC

A fundamental understanding of the process of fracture in brittle rock is important in a number of resource industries. For example, the

high stresses in the rock around deep mining excavations or waste repositories induce extensive fractures which can cause rockburst instabilities like minor earthquakes. Progress in this field is limited by the difficulty of performing adequate laboratory experiments to determine the fundamental damage processes that take place at the microscopic level and the cascade to meso and macroscopic length scales. With the advent of more powerful computers it has now become possible to perform micro-scale numerical experiments to explore the fracture processes. It is therefore timely to hold a workshop which brings together mathematicians, computational scientists, and physicists to attempt to build the appropriate continuum and statistical mechanical models of fracture.

Participants: Léon Beugelsdijk (Delft University of Technology), Peter Cundall (Itasca Consulting Group, Inc.), Christine Detournay (Itasca Consulting Group, Inc.), Emmanuel Detournay (University of Minnesota), John Goldak (Carleton University), M. A. "Curt" Koenders (Kingston University), Jack Kolle (Tempress Technologies, Inc.), Matthew R. Kuhn (University of Portland), Alan C. Mueller (Tempress Technologies, Inc.), Chris Myers (Cornell University), John Napier (Department of Mining Technology, CSIR), Anthony Peirce (University of British Columbia), David Place (The University of Queensland), David Potyondy (Itasca Consulting Group, Inc.), Dr. Hide Sakaguchi (Kobe University)

The number of participants was limited to keep the workshop small enough that it is possible for each person to contibute to the discussion and developments. There were a limited number of talks to try to present the state of the art in the different fields and to outline the outstanding problems. These were followed by discussion groups in which participants worked on the problems that have been posed.

First Annual PIMS PDF Meeting, UBC, September 12–13, 1998

Organizer: Alexander Rutherford, PIMS

At this meeting, Post Doctoral Fellows from all of the PIMS sites gave talks on their work. The format of the meeting was informal to allow plenty of time for discussion and exchange of ideas. Everybody, including faculty members and graduate students, were encouraged to attend. Talks were held in the Mathematics Annex, room 1102, on the UBC campus.

Speakers:

Malek Abdesselam (UBC), "Rigorous Renormalization Group"

Siva Athreya (Fields Inst.), "Existence of Positive Solutions Satisfying the Boundary Harnack Principle for a Semi-linear Dirichlet Problem"

C. Sean Bohun (UVic), "Existence, Uniqueness and Asymptotic Behaviour of the Wigner-Poisson System with an External Coulomb Field"

Dan Calistrate (UC), "Real Option Models for the Energy Sector"

Stephen Choi (SFU & UBC), "Polynomials with Restricted Coefficients"

Marina Gavrilova (UC), "Exact Computation Methods in Geographical Information Systems (GIS)"

Rachid Ait Haddou (UC), "Finsler Geometry and Inhomogeneous-anisotropic Continua"

Rostyslav Hryniv (UC), "Perturbations of analytic matrix functions"

Chris Jessop (UC), "3D Models of Geological Structures"

Sadok Kallel (UBC), "Configuration Space Models in Topology"

Yves Lucet (UA, SFU and UVic), "Computational Convex Analysis"

Pierre Marechal (SFU), "Issues in Medical Imaging"

Dave McNeilly (UA), "On the Weil Representations"

Martin Schlottmann (UA), "Self-Similar Tilings and p-adic Numbers"

John Stockie (SFU), "Moving Mesh Methods for Hyperbolic PDEs"

Holger Teismann (UVic), "Some Singular Schrvdinger-type Equations Appearing in Mathematical Physics"

James Watmough (UVic), "Intra-nest Transmission of Honey Bee Pheromones"

Bruce Watson (UC), "Inverse Sturm-Liouville Problems with Eigenparameter Dependent Boundary Conditions"

4.4 Extra-Thematic Scientific Workshops for 1999

Computational Graph Theory and Combinatorics, University of Victoria, May 6-8, 1999

Organizers: Wendy Myrvold and Frank Ruskey (Department of Computer Science, University of Victoria)

The PIMS sponsored Workshop on Computational Graph Theory and Combinatorics was held at the University of Victoria, May 6-8. The workshop attracted more than 70 attendees and featured invited talks by three distinguished mathematical scientists. Herbert Wilf (University of Pennsylvania) gave a talk entitled "East-West, a Recursive Package for Generating Combinatorial Families". Brendan McKay (Australian National University) gave a talk entitled "Generating Representatives of Isomorphism Classes". Steven Skiena (SUNY Stonybrook) gave a talk entitled "Who is interested in algorithms and why?: lessons from the Stony Brook Algorithms Repository". In addition Brendan McKay gave a public lecture "The Bible Code: Fact or Fallacy" (partially sponsored by the UVic Lansdowne Fund). There were 30 contributed talks given by speakers from around the world: The countries represented include France, Belgium, Germany, Poland, Australia, and the U. S. A.

Participants Include: Timothy Walsh (University of Quebec), Dominique Roelants van Baronaigien (University of Victoria), Joe Sawada (University of Victoria), Veerle Fack (University of Ghent), S. Lievens (University of Ghent), J. Van der Jeugt (University of Ghent), Herb Wilf (University of Pennsylvania), Charles Colbourn (University of Vermont), Joe Peters (Simon Fraser University), Yontha Ath (Claremont Graduate University), Milton Sobel (University of California, Santa Barbara), Stephen Ryan, Lhouari Nourine (Universite Montpellier), Oliver Raynaud (Universite Montpellier), Julian West (Malaspine Unversity-College, Nanaimo), Brendan McKay (Australian National University), Thomas Harmuth, Konrad Piwakowski (Technical University of Gdansk, Poland), Stanislaw P. Radziszowski (Rochester Institute of Technology), Brian Blitz, Brendan McKay (Australian National University), Malcolm Greig (Greig Consulting), David Pike (Memorial University of Newfoundland), Nabil Shalaby (Memorial University of Newfoundland), Frank Ruskey (University of Victoria), Stirling Chow, Pierre Hansen (GERAD and Ecole des Hautes Etudes Commerciales de Montreal), Gilles Caporossi (Ecole Polytechnique de Montreal), Janez Ales, Joshua Madden (University of British Columbia), Richard Anstee (University of British Columbia), Moshe Rosenfeld (Pacific Lutheran University), Larry Cummings (University of Waterloo), Jack Snoeyink (University of British Columbia), Bettina Speckmann (University of British Columbia), Perry Fizzano (University of Puget Sound), Arvind Gupta (Simon Fraser University), Ramesh Krishnamurti (Simon Fraser University), Stephane Durocher (University of British Columbia), David Kirkpatrick (University of British Columbia), Steve Skiena (SUNY Stony Brook, New York), Wendy Myrvold (University of Victoria), Jianping Roth (Seagate Software), Mike Fellows (University of Victoria), Louis Goddyn (Simon Fraser University), Andrzej Proskurowski (University of Oregon), Jan Arne Telle (University of Bergen, Norway), Prosenjit Bose (Carleton University), William Evans (University of Arizona), David Kirkpatrick (University of British Columbia), Dean Hoffman (University of Auburn)

XIVth Householder Symposium on Numerical Linear Algebra, Chateau Whistler, June 14-18, 99

Local Organizer: Jim Varah, UBC.

The Householder Symposia originated in a series of meetings organized by Alston Householder, Director of the Mathematics Division of Oak Ridge National Laboratory and Ford Professor at the University of Tennessee. These international meetings were devoted to matrix computations and linear algebra and were held every three years at Gatlinburg, Tennessee. They had a profound influence on the subject.

The last "Gatlinburg" conference was held in1969 on the occasion of Householder's retirement. At the time it was decided to continue the meetings but vary the place. Since then meetings have been held at three year intervals at Los Alamos, USA; Hopfen am See, Germany; Asilo-

mar, USA; Oxford, England; Waterloo, Canada; Fairfield Glade, USA; Tylosand, Sweden; Lake Arrowhead, USA; and Pontresina, Switzerland.

The meetings, which last for five days, are restricted to about 125 people. They are intensive, with plenary talks in the day and special sessions in the evenings. To encourage people to talk about work n progress, no proceedings are published, although extended abstracts are circulated. The response of the participants to the meetings has been uniformly enthusiastic.

The conferences are run in tandem by a permanent organizing committee and a local arrangements committee. Although attendance is restricted, anyone - including students - can apply. Selection is made by the organizing committee, generally by ballot.

The meeting is also the occasion for the award of the Householder prize for the best thesis in numerical linear algebra. This prize is entirely (and well) supported by contributions solicited at the Symposium banquet.

Programme Committee: Pete Stewart, (Maryland) **Ake Björck**, (Linköping), **Angelika Bunse-Gerstner**, (Bremen), **Tony Chan**, (Los Angeles), **Chandler Davis**, (Toronto), **Alan George**, (Waterloo), **Nick Higham**, (Manchester), **Dianne O'Leary**, (Maryland), **Paul Van Dooren**, (Louvain-la-Neuve), **Charles Van Loan**, (Cornell).

First Canadian Conference on Nonlinear Solid Mechanics, University of Victoria, June 16-20, 99

Intended to attract engineers, applied mathematicians, physicists, chemists, software experts, and industrial practitioners, this conference provides an international forum for communicating recent and projected advances in various areas of Nonlinear Solid Mechanics by assembling researchers working on common themes from complementary perspectives.

Invited Speakers

A. J. M. Spencer, University of Nottingham, UK
R. W. Ogden, University of Glasgow, Scotland
T. Belytschko, Northwestern University, USA
M. Hayes, University College Dublin, Ireland
M. S. Gadala, University of British Columbia

Organizing Committee

E. M. Croitoro, University of Victoria (Chair)
B. Tabarrok, University of Victoria
J. B. Haddow, University of Victoria
D. J. Leeming, University of Victoria
M. S. Gadala, University of British Columbia
G. A. C. Graham, Simon Fraser University
M. Epstein, University of Calgary
P. Schiavone, University of Alberta
T. Bryant Moodie, University of Alberta
Y. C. Chen, University of Houston
D. J. Steigmann, University of California, Berkeley

PIMS Workshop on Smoothing Applications, UBC, June 23-25, 1999

Organizers: Nancy Heckman (UBC), Kiros Berhane (University of Southern California), Hans Mueller (UC Davis), Jane-Ling Wang (UC Davis), Doug Nychka (North Carolina State University and National Center for Atmospheric Research), Jim Ramsay (McGill), John Rice (UC Berkeley).

The emphasis of the workshop is on the applications of smoothing methods to data. Several sessions will be centred around discussion of specific datasets. Other sessions will consist of more traditional-style presentations.

Other participants: Charmaine Dean, Simon Fraser University, **Piet de Jong**, University of British Columbia, **Joel Dubin**, UC Davis, **Irene Gijbels**, Catholic University of Louvain, **Jarek Harezlak**, Indiana University School of Medicine, **Jianhua Huang**, University of Pennsylvania, **Brad Love**, UC Davis, **Peter Hooper**, University of Alberta.

PIMS Summer Workshop on Invariants of Three Manifolds, Nakoda Lodge, July 18–22, 1999

Organizers: John Bryden (University of Calgary), David Hobill (University of Calgary), Peter Zvengrowski (University of Calgary).

This workshop will focus on problems pertaining to invariants of three manifolds and topological quantum field theory. Invited speakers will give morning lectures on their recent work and

afternoon sessions will be devoted to discussions and more informal seminars.

Invited Speakers: D. Auckly, (Kansas State University), **J. Bryden**, (University of Calgary), **L. Crane**, (Kansas State University), **F. Deloup**, (Université Paul Sabatier), **C. Hayat-Legrand**, (Universit Paul Sabatier), **R. Kirby**, (University of California at Berkeley), **R. Lawrence**, (University of Michigan), **T. Le**, (SUNY at Buffalo), **L. Rozansky**, (Yale University), **A. Tralle**, (Max Planck Inst. fü Mathematik, Bonn), **V. G. Turaev**, (Université of Louis Pasteur), **O. Viro**, (Uppsala Universitet), **K. Varadarajan**, (University of Calgary), **H. Zieschang**, (Ruhr University at Bochum).

International Symposium on Symbolic and Algebraic Computation, SFU Harbour Centre, July 28–31, 1999

Organizing Committee:
Keith Geddes, (U. of Waterloo, General Chair), Bruno Salvy (INRIA Rocquencourt, Programme Chair), Michael Monagan (SFU, Local Arrangements)

The International Symposium on Symbolic and Algebraic Computation (ISSAC) is a yearly international symposium that provides an opportunity to learn of new developments and to present original research results in symbolic mathematical computation. Topics covered at the meeting include algorithmic mathematics, computer science, and applications to engineering, economics and finance, physical and biological sciences, computer science, logic, mathematics, statistics, and use in education.

Workshop on Algorithms and Data Structures, SFU Harbour Centre, Aug. 11-14, 1999

Organizers: Binay Bhattacharya, Arvind Gupta, Arthur Liestman, Thomas Shermer, Simon Fraser University.

The Workshop, which alternates with the Scandinavian Workshop on Algorithm Theory, is intended as a forum for researchers in the area of design and analysis of algorithms and data structures. The workshop features papers with original research results on the theory and application of algorithms and data structures in all areas, including combinatorics, computational geometry, databases, graphics, parallel and distributed computing, and cryptography. This year's WADS will be the lead event for the PIMS-Fields special year on Graph Theory and Combinatorial Optimization.

Programme Committee: A. Gupta (SFU), **F. Dehne** (Carleton), **J.-R. Sack** (Carleton), **R. Tamassia** (Brown), **A. Andersson** (Uppsala), **A. Apostolico** (Purdue and Padova), **G. Ausiello** (Rome), **G. Bilardi** (Padova), **K. Clarkson** (Lucent), **R. Cleve** (Calgary), **M. Cosnard** (INRIA-LORIA, France), **L. Devroye** (McGill), **P. Dymond** (York), **M. Farach-Colton** (Rutgers), **P. Fraigniaud** (Paris), **M. Goodrich** (Johns Hopkins), **A. Grama** (Purdue), **M. Keil** (Saskatchewan), **D. Kirkpatrick** (UBC), **R. Krishnamurti** (SFU), **D.T. Lee** (Northwestern), **F. Luccio** (Pisa), **A. Maheshwari** (Carleton), **G. Plaxton** (Univ. of Texas at Austin), **A. Rau-Chaplin** (Dalhousie), **J. Reif** (Duke), **F. Ruskey** (U. Vic), **P.G. Spirakis** (Patras), **L. Stewart** (Alberta), **H. Sudborough** (U. Texas Dallas), **P. Vitanyi** (CWI), **P. Widmayer** (ETH), **C.K. Wong** (Chinese U. Hong Kong).

International Workshop on the Analysis of Vibrating Systems, Canmore, Alberta, Sept. 26-28, 1999

Organizers: Peter Lancaster, Marc Paulhus, Joanne Longworth (University of Calgary)

The objectives for this intensive three day workshop are the discussion of recent advances in the analysis of vibrations (including discrete and distributed systems and symmetry groups), and the identification of developing problem areas in the analysis of vibrations. In particular, there will be: Exchange of ideas between those working with linear and non-linear models; vibrations being the common ground, Dialogue between researchers in engineering, the mathematical sciences, and industry. The topics includes: Control, Stability, Sound and Vibration, Inverse Problems, Perturbation Theory, Nonlinear Systems, Hamiltonian Systems, Gyroscopic Systems, the role of Operator Theory and Industrial Problems.

Invited Speakers:

- **Vadim Adamyan** on Sturm-Liouville Operators on Directed Graphs,
- **Shuh-Jye Chern** on Stability Analysis for Dissipative Hamiltonian Systems,
- **Graham Gladwell** on Some Qualitative Properties of Vibrating Systems,
- **Israel Gohberg** on State Space Methods in Problems of Mathematical Analysis,
- **Peter Hagedorn** on Vortex Excited Vibrations of Overhead Transmission Lines Modelling and Numerical Problems,
- **Naomi Leonard** on Stabilization with Controlled Lagrangians,
- **Alexander Lipton** on Spectral Properties of Differentially Rotating Stars,
- **Joyce McLaughlan** on Using Selected Mode Shape Data to solve Inverse Problems,
- **Sri Namachchivaya** on Nonlinear Dynamics of Gyroscopic and Aeroelastic Systems,
- **Jim Woodhouse** on Self-excited Vibration of Bowed Strings and Modelling the Playing of Violins.

11th Canadian Conference on Computational Geometry, UBC, Aug. 15–18, 1999

Organizers: Jack Snoeyink and David Kirkpatrick (UBC)

Invited Speakers: John Canny (UC Berkeley), Susanne Fortier (Queen's, to be confirmed), Victor Klee (Univ. of Washington)

This conference focuses on the mathematics of discrete geometry from a computational point of view. CCCG traditionally attracts a large number of students because of its workshop atmosphere and because conference costs are kept low by using accommodation in dorms and student volunteers.

10th International Workshop and Conference in Stochastic Geometry, Stereology & Image Analysis, University of Calgary, August 24–28, 1999

Organizers: Ernest Enns, Math. & Stat., University of Calgary, Peter Ehlers, Math. & Stat., University of Calgary and John Matyas, Anatomy, University of Calgary.

This meeting is aimed at active research workers in the fields of Stereology, Stochastic Geometry and Image Analysis. This includes Statisticians, Mathematicians, Pathologists, Material Scientists and Computational Experts. Graduate students are encouraged to attend and participate in the workshop. The workshop will make use of the Stereology Resource Centre at the University of Calgary, which was formed in 1996 primarily to meet the practical needs of biomedical researchers who need to make unbiased estimates of biological structure.

West Coast Operator Algebra Symposium, University of Victoria, October 16-17, 1999

Organisers: Bruce Blackadar (Nevada, Reno), Ed Effros (UCLA), John Phillips (U. Vic.), N. C. Phillips (Oregon), I. Putnam (U. Vic.) and D. Voiculescu (Berkeley)

This meeting is an annual forum for the large group of researchers currently working in the field of operator algebras on the west coast of North America. The meeting is held over a weekend each fall. Usually, there are about seven talks of about one hour each. The speakers are usually established people from the community, graduate students who are finishing their degrees, postdoctoral fellows and shorter term vistors to the region. Time is also allowed for informal interactions between participants. The intended audience is the research community on the west coast of North America in the field of operator algebras. There is opportunity for finishing Ph.D. students to speak on their work and also informally interact with senior researchers.

This meeting represents a broad and very active community. There are people/groups at all of the following "West Coast" institutions: U. C. San Diego, Cal. State San Bernadino, U. C. L. A., U.C. Santa Barbara, U. C. Berkeley, Arizona State U., U. Nevada Reno, U. Oregon, U. Victoria, U.N.B.C., U. of Calgary, U. of Alberta. Most years, most of these are represented.

The conference usually attracts about sixty participants.

Speakers Include: D. Bisch (U. C., Santa Barbara), V. F. R. Jones (Berkeley) (invited, but not confirmed), H. Lin (Oregon), M. Rieffel (Berkeley). Three aditional speakers will be chosen.

4.5 Pacific Northwest Seminar Series

These are annual or bi-annual meetings that bring together various regional groups of mathematicians in areas represented by strong communities in British Columbia, Alberta, Washington, Oregon and Northern California. Some of the scientific goals of the Pacific Institute, e.g. promoting communication among mathematical scientists, have been served by *ad hoc* organizations formed in Western Canada and the U. S. Pacific Northwest.

PNW Probability Seminar

This is an annual seminar held by the probability groups at UBC, U. of Washington and Oregon State University. Traditionally it has alternated between UBC and U. of Washington although in the last few years it has been hosted by U. of Washington due to its central location. It usually attracts 25-30 participants including 8-10 from UBC and gives the groups a chance to interact with each other. As these are among the strongest probability groups in N. America it has been easy to attract outstanding scientists as speakers. This is also a good way for these groups to share many of the visiting scientists with the other sites.

Scientific advisory committee: Martin Barlow (UBC), Richard Bass (UW), Chris Burdzy (UW), Ed Perkins (UBC), Ed Waymire (OSU).

During 1998, PIMS sponsored PNW Probablility Seminars on March 7 and November 7.

PNW Workshop on Math Biology

This spring the University of Washington hosted the annual Pacific Northwest Workshop on Mathematical Biology (PNWWMB — fondly the punawumba). The meeting, organised by Tom Daniel was held on Saturday, March 26–28, 1998 at the University of Washington. It was supported by the University of washington and the NSF. PIMS provided funding to cover the expenses of Canadian graduate students.

PNW Number Theory Seminar

During 1998, PIMS sponsored the PNW Number Theory Seminar held on May 2, 1998 at the Harbour Centre campus of Simon Fraser University. The organizers were Peter Borwein (Simon Fraser U.), David Boyd, (U. British Columbia) and Joe Buhler (Reed College). The speakers are Joe Buhler (Reed College) and Fernando Rodriguez Villegas (U. Texas, Austin), Michael Bennett (U. Illinois, Urbana-Champaign and Institute for Advanced Study), Rajiv Gupta (University of British Columbia), Chris Skinner (Institute for Advanced Study), and Fernando Rodriguez Villegas (U. Texas).

The most recent PNW Number Theory Seminar was held at the University of Washington on April 17, 1999. The organizers are Joe Buhler (Reed College) and Ralph Greenberg (U. Washington). The invited speakers were: Bill Casselman (UBC), Adrian Iovita (U. Washington), Karl Rubin (Stanford) and John Tate (U. Texas).

PNW Optimization Seminar

The West Coast Optimization Meeting takes place twice each year, usually in April and November, and alternates between Vancouver and Seattle. In Vancouver, SFU/CECM and UBC/Math share the hosting duties, with local contacts Jonathan M. Borwein and Philip D. Loewen. In Seattle, UW/Math and UW/Applied Math contribute the organizational personnel: R. T. Rockafellar and J. V. Burke do most of the work. The meetings involve an informal get-together for social and technical discussions on Friday evening, followed by a series of talks on

Saturday. Speakers are drawn from the considerable body of optimization talent now gathered in the five PIMS partner sites, the University of Washington, and Washington State University; a featured guest from outside is usually invited to round out the programme.

PIMS sponsored the last meeting, which was held at the Harbour Centre Campus of Simon Fraser University on April 23–24, 1999. The speakers were

Heinz Bauschke (Okanagan University College), "A weak-to-strong convergence principle for Fejer-monotone methods in Hilbert space"

Jane Ye (University of Victoria), "Constraint Qualifications and Necessary Optimality Conditions for Optimization Problems with Variational Inequality Constraints"

Pierre Marechal (PIMS, Simon Fraser University, CECM) "On Radon-type inverse problems"

Levent Tuncel (University of Waterloo) "Combinatorics and Optimization Cones of matrices and successive convex relaxations of nonconvex sets"

Marian Fabian (Czech Academy of Sciences) "Stegall's smooth variational principle and its applications"

Yves Lucet (PIMS, University of Victoria) "How do you build a smooth convex interpolant?"

Grant Galbraith (University of Washington) "Cosmic Sub-Lipschitz Mappings and Applications"

Cascade Topology Seminar

This is a twice-yearly seminar which rotates among universities of the US Pacific Northwest, and western Canada. Its purpose is to gather topologists of the region, and present lectures on recent progress in the field, at an informal weekend meeting. It was originally modelled after the Pacific Northwest Geometry Seminar, and there is some overlap in the audiences. Like the PNGS, the Cascade seminars are very successful, and have been supported (for the US meetings only) by the US National Science foundation. The meetings are informal and friendly, and a special effort is made to encourage participation by graduate students by providing their housing costs.

The 24th Cascade Topology Seminar will be held at the University of British Columbia on October 2-3, 1999 and will be sponsored by PIMS.

Western Canada Linear Algebra Meeting (W-CLAM)

W-CLAM is a (generally) bi-annual sequence of meetings on linear algebra and related fields; previous meetings have been held in Regina, Lethbridge and Kananaskis. The objective is to foster research in linear algebra and its applications. While the primary purpose of W-CLAM is to enable researchers (including graduate students) from Western Canada to get together to present current work and to exchange ideas, the meeting is open to anyone.

The last meeting was held at the University of Victoria on July 30-31, 1998. The Organizers were H. Kharaghani (Univ. of Lethbridge), P. Lancaster (Univ. of Calgary), S. Kirkland and M. Tsatsomeros (Univ. of Regina), D. Olesky and P. van den Driessche (Univ. of Victoria).

The Invited Speakers were **J. Seberry**. Dept CSc, Univ. of Wollongong, Australia who is an expert in Hadamard matrices and cryptography, and **S. Boyd**, Dept Electrical Engineering, Stanford Univ., Calif.

4.6 Joint CRM-Fields-PIMS Initiatives

27^{th} Canadian Operator Theory and Operator Algebras Symposium, May 20–24, 1999, University of Prince Edward Island

In conjunction with the Fields Institute, the Centre de Recherches Mathématiques and the Atlantic Association for Research in the Mathematical Sciences, PIMS is sponsoring the Canadian Operator Theory and Operator Algebras Symposium (COSY).

Organizer: Gordon MacDonald (University of Prince Edward Island)

Invited Speakers

Ken Davidson, University of Waterloo
George Elliott, University of Toronto
Liming Ge, University of New Hampshire
Don Hadwin, University of New Hampshire
David Handelman, University of Ottawa
David Larson, Texas A & M (featured speaker)
Steve Power, University of Lancaster
Ian Putnam, University of Victoria
Heydar Radjavi, Dalhousie University
Mikael Rordam, University of Copenhagen.

International Conference and Workshop on Valuation Theory, University of Saskatchewan, July 26 - August 11, 1999

Organizers: Andrew Carson, Franz-Viktor Kuhlmann, Salma Kuhlmann, Murray Marshall (University of Saskatchewan), Deirdre Haskell (College of the Holy Cross), Hans Schoutens (Wesleyan University).

This conference is dedicated to Paulo Ribenboim, in recognition of his extensive contributions to the subject. Tutorials will be given on July 26 and 27. The conference will be held from July 28 through August 4. There will be a special session in honor of Paulo Ribenboim on July 31, and the informal workshop will be held from August 5 through August 11.

The conference is intended to cover recent developments in valuation theory and its applications: algebraic geometry (especially local uniformization), real algebraic geometry (and quadratic forms), Galois theory, rigid analysis and curves over valuation rings, model theory of valued fields (especially in positive characteristic), o-minimal expansions of the reals (and Hardy fields), ultrametric spaces and spherically complete fields, p-adic numbers, noncommutative valuation theory.

The main topics of the Workshop will be: Local uniformization and resolution of singularities, model theory of valued fields in positive characteristic and its connections with resolution of singularities, the theory of valued function fields, approximate roots and related subjects, o-minimal expansions of the reals and Hardy fields. In addition to these subjects, the workshop will offer an opportunity to discuss other recent developments and open problems which are connected to the scientific programme of the conference.

Confirmed Speakers:

Shreeram Abhyankar (Purdue), **Carlos Andradas** (Madrid), **Ron Brown** (Hawaii), **Alexandru Buium** (Urbana), **Gilles Christol** (Paris), **Vincent Cossart** (Versailles), **Michel Coste** (Rennes), **Tom Craven** (Hawaii), **Dale Cutkosky** (Missouri), **Nikolai Dubrovin** (Vladimir), **Yuri Ershov** (Novosibirsk), **Jose Engler** (Campinas), **Joachim Graeter** (Potsdam), **Urs Hartl** (Ulm), **Roland Huber** (Wuppertal), **Sudesh Khanduja** (Chandigarh), **Hagen Knaf** (Heidelberg), **Jochen Koenigsmann** (Konstanz), **Leung Ka Hin** (Singapore), **Quing Liu** (Bordeaux), **Francois Loeser** (Paris), **James Madden** (Baton Rouge), **Jan Minac** (Western Ontario), **Freddy van Oystayen** (Antwerpen), **Olivier Piltant** (Paris), **Florian Pop** (Bonn), **Patrick Popescu-Pampu** (Paris), **Victoria Powers** (Emory), **Ana Reguera** (Valladolid), **Paulo Ribenboim** (Kingston), **Peter Roquette** (Heidelberg), **Mohamed Saidi** (Bonn), **Thomas Scanlon** (Berkeley), **Claus Scheiderer** (Regensburg/Duisburg), **Erwin Schoerner** (Munich), **Niels Schwartz** (Passau), **John Shackell** (Canterbury), **Patrick Speissegger** (Toronto), **Michel Vaquie** (Paris), **Adrian Wadsworth** (San Diego).

AARMS Combinatorics Workshop, Memorial University, May 24–28, 1999

The 3 institutes are supporting this Combinatorics Workshop at the upcoming CMS Summer Meeting. This event, which is organized by the *Atlantic Association for Research in the Mathematical Sciences,* focus on problems in combinatorial designs and applications. It will invlove a series of lectures given by some of the invited speakers at the session on Combinatorics and its Applications at the CMS Summer Meeting. The organizers of the workshop are J. Brown (Dalhousie), R. Nowakowski (Dalhousie), A. Punnen

(UNB) and N. Shalby (Memorial).

Seminaire de Mathématiques Superieures, Integrable Systems: From Classical to Quantum, Université de Montréal, July 26 – August 6, 1999

This purpose of this seminar is to review recent developments in Integrable Systems, particularly in the quantum domain. The principal lecturers will give mini-courses of 4 or 5 lectures that will be accessible to graduate students and young researchers newly entering the domain. The Canadian organizers are John Harnad (Concordia), Luc Vinet (Director, CRM) and Pavel Winternitz (U. de Montréal).

Principal Speakers: Denis Bernard (Saclay), Boris Dubrovin (SISSA, Trieste), John Harnad (Concordia University and CRM), Alexander Its (Indiana University), Vladimir Korepin (SUNY at Stony Brook), Andre Leclair (Cornell University), Tetsuji Miwa (RIMS, Kyoto), Alexios Polychronakos (University of Ioannina, Greece), Nicolai Reshetikhin (University of California, Berkeley), Simon Ruijsenaars (Amsterdam), Evgueni Sklyanin (St. Petersburg and University of Leeds), Craig A. Tracy (University of California, Davis), Pavel Winternitz (Université de Montréal)

Special Session on Mathematical Physics at the CMS Winter Meeting, Université de Montréal, December 11–13, 1999

PIMS is one of the sponsors of the Special Session on Mathematical Physics at the 1999 CMS Winter Meeting. This session, which is organized by George Bluman (University of British Columbia), Michel Grundland (UQTR), and Gordon Slade (UBC) will feature talks on:

I. Probability methods and applications

II. Group theory methods and application

4.7 PIMS International Initiatives

First Pacific Rim Conference on Mathematics, City University of Hong Kong, Hong Kong, January 19-23, 1998

Organizers: Fon-Che Liu, Academia Sinica, Taiwan Robert M. Miura, University of British Columbia, Canada, Roderick S.C. Wong, City University of Hong Kong, Hong Kong.

The First Pacific Rim Conference on Mathematics was specifically organized to bring mathematicians from Pacific Rim countries together. This first Conference was open to all areas of mathematics. There was a focus on nine specific areas of mathematics: namely, there were sessions in analytic number theory, applied analysis, calculus of variations, combinatorics, computational complexity, geometric analysis, optimization, pdes - pulse dynamics, and probability. These specific topics were chosen since they represent areas of strength in Pacific Rim countries. The scientific objectives of this Conference are to disseminate recent research results to a wide audience and to develop stronger ties between mathematicians around the Pacific Rim. The main sponsors of this Conference are Canada, Hong Kong (PRC), and Taiwan.

Programme:

- Analytic Number Theory
  John Friedlander, U. of Toronto (Plenary)
  Mike Bennett, U. of Illinois and IAS
  Kai-Man Tsang, U. of Hong Kong

- Applied Analysis
  P.L. Lions, U. de Paris-Dauphine (Plenary)
  Mark Ablowitz, U. of Colorado
  Martin Kruskal, Rutgers U.
  Tai-Ping Liu, Stanford U.,
  Gilbert Strang, M.I.T

- Calculus of Variations
  M. Giaquinta, U. of Pisa (Plenary)
  Jin-Tzu Chen, National Taiwan U.
  G. Dal Maso, SISSA, Trieste

- Combinatorics
  Fan Chung, U. of Pennsylvania (Plenary)
  Dingzhu Du, U. of Minnesota
  Frank K. Hwang, National Chiao Tung U.
  Khee Meng Koh, Singapore National U.
  Yeong-Nan Yeh, Academia Sinica, Taipei

- Computational Complexity
  Manuel Blum, City U. of Hong Kong (Plenary)
  Allan Borodin, U. of Toronto
  Dimitri Grigoriev, Pennsylvania State U.

- Geometric Analysis
  Shing-Tung Yau, Harvard U. (Plenary)
  Jih-Hsin Cheng, Academia Sinica, Taipei
  Jiaxing Hong, Fudan U.
  Chang-Shou Lin, National Chung Cheng U.
  Luen Fai Tam, Chinese U. of Hong Kong
  I-Hsun Tsai, National Taiwan U.

- Optimization
  Margaret Wright, Bell Laboratories (Plenary)
  Jong-Shi Pang, Johns Hopkins U.
  Gianni Di Pillo, U. of Rome - La Sapienza
  Liqun Qi, The U. of New South Wales
  Yinyu Ye, U. of Iowa

- PDEs - Pulse Dynamics
  Masayasu Mimura, U. of Tokyo (Plenary)
  Neil Balmforth, U. of Nottingham
  Ehud Meron, Bar Shiva U., Israel
  Michael Ward, U. of British Columbia
  Eiji Yanagida, U. of Tokyo

- Probability
  Krzysztof Burdzy, U. of Washington (Plenary)
  Theodore Cox, Syracuse U.
  Naohisa Funaki, U. of Tokyo
  Zhi-Ming Ma, Academia Sinica, PRC
  Edwin Perkins, U. of British Columbia
  Gordon Slade, UBC

Additional funding was provided by the City University of Hong Kong, The Croucher Foundation, Hong Kong Pei Hua Education Foundation Limited, K.C. Wong Education Foundation and the Lee Hysan foundation Limited.

Fifth International Workshop on Mathematical Aspects of Fluid and Plasma Dynamics, Wailea, Maui, Hawaii June 28 – July 3, 1998

Organisers: Reinhard Illner, University of Victoria, B.C., Marshall Slemrod, University of Madison, Wisconsin, Seiji Ukai, Tokyo Institute of Technology.

Organizing institutes and sponsors: The Pacific Institute for the Mathematical Sciences, The Maui Research and Technology Centre, The Tokyo Institute of Technology, The Center for Mathematical Sciences, University of Madison, Wisconsin.

Participation at this meeting was only by invitation. The objective of the conference is to give leading researchers in the mathematics of fluids, plasmas, stellar systems and rarefied gas dynamics the opportunity to present recent progress and learn about new directions and tools. In particular, there were representatives of new directions like the kinetic theory of semiconductors, kinetic models in granular flow, and others.

The scope of the meeting included theory and application of: the Boltzmann equation and related equations, the Vlasov-Poisson system and related equations, transport Phenomena in semiconductors, quantum kinetic models, applications of kinetic models in flow phenomena (e.g., granular flow), Navier-Stokes and Euler equations, Particle simulations.

List of participants: Chris Bose (University of Victoria), John Heywood (UBC), Reinhard Illner (University of Victoria), A. Lawniczak (University of Toronto), Fausto Milinazzo (Victoria), Brian Wetton (UBC), Hakan Andreasson (University of Goeteborg), Mark Andrews (University of Honolulu), Marcello Anile (University of Catania), Kazuo Aoki (University of Kyoto), Leif Arkeryd (University of Goeteborg), Anton Arnold (TU Berlin), Kiyoshi Asano (University of Kyoto), Hans Babovsky, Claude Bardos (Université Paris VII), Naoufel Ben Abdallah (Toulouse), Silvia Bertoluzza (Universita di Pavia), Graeme Bird (Sydney), Alexander Bobylev (Keldysh Institute) (Moscow), Vinicio Boffi (Rome), Luis Caffarelli (Austin), Russel Caflisch (UCLA), Eric Carlen (Georgia Inst. of Tech.), Carlo Cercignani (Politecnico di Milano), Dongho Chae (Seoul), Hi Jun Choe (Taejon), Peter Constantin (University of Chicago), Costas Dafermos (Brown University), Wakako Dan (Tsukuba), S. G. Deshpande (Bangalore), Laurent Desvillettes (Université de Orleans), Robert Dewar (Canberra), Jack Dorning (University of Virginia Charl.), Raffaele Esposito (University of Rome), Yasuhide Fukumoto (Fukuoka), Irene Gamba (Univer-

sity of Austin), Carl Gardner (University of Ariz.), Ingo Gasser (TU Berlin), Renee Gatignol (Université Paris VI), Bob Glassey (University of Indiana), Isaac Goldhirsch (Tel Aviv), Francois Golse (Université Paris VII), Jim Greenberg (University of Pittsburgh), Yan Guo (Courant Institute), Roger Hosking (University of Queensland), J. W. Jerome (Northwestern University), Shi Jin (Georgia Insitute of Technology), Yoshiyuki Kagei (Fukuoka), Shuichi Kawashima (Fukuoka), Axel Klar (Uni. Kaiserslautern), Hideo Kozono (Nagoya), Maria Lampis (Politecnico di Milano), Horst Lange (University of Cologne), Joel Lebowitz (Rutgers University), David Levermore (University of Arizona, Tucson), Richard Liboff (Cornell), Tai-Ping Liu (Stanford University), Peter Markowich (TU Berlin), Tetsuro Miyakawa (Fukuoka), Joe Monaghan, Hiroko Morimoto, Philip Morrison (University of Texas), Norbert Mauser (TU Berlin), Helmut Neunzert (Uni. Kaiserslautern), Takaaki Nishida, (University of Kyoto), Ohwada (University of Kyoto), Takayoshi Ogawa (Nagoya), Hisashi Okamoto (University of Kyoto), Dmitri Petrina (Kiev), Paola Pietra (Universita di Pavia), Frederic Poupaud (Université de Nice), Mario Pulvirenti (Universita di Roma), Rolf Rannacher, (Universität Heidelberg), Michel Rascle (Université de Nice), S. Rjasanow (Universität Saarbruecken), Michael Ruzicka (University of Vienna), Christian Schmeiser (University of Vienna), Maria E. Schonbek (University of California), Yoshihiro Shibata (Brown University), Tsukuba C.-W. Shu (Brown University), Juan Soler (University of Granada), Marshall Slemrod (University of Madison), Yoshio Sone (University of Kyoto), Struckmeier (Uni. Kaiserslautern), Tak Sugimura (Maui Research and Tech. Ctr.), Shuji Takahashi (Tokyo), Atushi Tani (Keio University, Yokohama), Giuseppe Toscani (University of Pavia), Takata (University of Kyoto), Tai-Peng Tsai (University of Minneapolis), Seiji Ukai (Tokyo Institute of Technology), Raghu Varadhan (Courant Institute), H. Dean Victory (Texas Tech University) M. Cedric Villani (Université Paris VI), Wolfgang Wagner (Inst. für Angewandte Math. und St.), Bernt Wennberg (University of Goeteborg), Kun Xu (Hong Kong), Paul Zweifel (Virginia Polytechnic Inst.)

First Canada-China 3×3 Math Congress, Tsinghua University, August 23–28, 1999

Organizers: N. Ghoussoub (Director, PIMS), K.C. Chang (President, Chinese Math Society), L. Peng (Director, Math Institute, Beijing University), D. Cai (Director, Math Institute, Tsing Hua University), X.-W. Zhou (Director, Math Institute, Nankai University), S. Halperin (Programme Leader, MITACS), D. Dawson (Director, Fields Institute), R. Kane (President, Canadian Math Society), L. Vinet (Director, CRM)

This congress will be the starting point for the establishment of scientific collaboration and provide clear directions for specific future projects.

List of Canadian Participants:

- **University of Toronto:** Kumar Murty, John Friedlander, John Bland, Fiona Murghnahan, Jeremy Quastel, Steve Halperin, George Elliott, Jim Arthur, Luis A. Seco
- **University of British Columbia:** Rajiv Gupta, Changfeng Gui, JingYi Chen, Jim Carrell, Kai Behrend, John Walsh, Brian Wetton, Dale Rolfsen, Anthony Peirce, Michael Ward, Uri Ascher
- **University of Alberta:** Alfred Weiss, Arturo Pianzola, Byron Schmuland, N. Tomczak-yaegermann
- **Queen's University:** Ram Murty, James Mingo
- **University of Victoria:** Reinhard Illner
- **McGill University:** Nicky Kamran, Jacques Hurtubise, Henri Darmon
- **McMaster University:** Maung Min-oo, Shui Feng, Alexander Rosa, Ian Hambleton, Andrew Nicas
- **Université du Québec à Montreal:** Steve Boyer
- **Universite du Montreal:** Abraham Broer, Gert Sabidussi
- **Centre de Recherches Mathématiques (CRM):** Luc Vinet, Jean-Marc Lina, Langis Gagnon, Michel Delfour
- **Fields Institute for Research in Mathematical Sciences:** Don Dawson, Andrew Dean, W.F. Langford, Guihua Gong
- **Pacific Institute for the Mathematical Sciences (PIMS):** Nassif Ghoussoub, Arvind Gupta, Huaxiong Huang, Alexander Rutherford
- **York University:** Tom Salisbury
- **University of Waterloo:** Edward R. Vrscay, Sue Ann Campbell
- **University of Waterloo:** D. R. Stinson
- **Simon Fraser University:** Stella Atkins, Robert D. Russell, Brian Alspach
- **Universite Laval:** Michel Fortin

- **Memorial University of Newfoundland:** Herman Brunner
- **University of Ottawa:** Thierry Giordano
- **University of Western Ontario:** Richard Kane, Mosound Khalkhali
- **Dalhousie University:** Shigui Ruan
- **IBM T. J. Watson Labs:** W. Pulleyblank
- **SUNY at Buffalo:** Xingru Zhang

Chapter 5

PIMS Industrial Initiatives: 1998–99

The PIMS industrial strategy is to establish on-going contacts and collaborations between PIMS academic and industrial members. It has been a priority for PIMS to identify research opportunities with the industrial sector. Towards this objective, PIMS has developed the following initiatives.

5.1 PIMS Forum on Industrial Mathematics, SFU-U. Calgary, 1998

This annual forum features a series of events over two weeks designed to bring together academic scientists, graduate students, and industrial researchers in the mathematical sciences to investigate industrial mathematics. In 1998, the basic format consisted of:

- The *PIMS Graduate Industrial Mathematics Modeling Camp* where graduate students from Canadian universities came together for one week to learn various aspects of high-level techniques for solving industrial mathematics problems. The participants work in small groups learning the most recent modelling techniques from experts in the field. The students came away with a foundation for understanding and contributing to the next two events:
- A PIMS sponsored *Canadian Applied Mathematics Society meeting* at Harbour Center May 28-31 (See Chapter 4).
- The *Second PIMS Industrial Problem Solving Workshop* described below.

Graduate Industrial Mathematical Modeling Camp, SFU, May 25–29 1998

Organisers: Arvin Gupta (SFU), Huaxiong Huang (PIMS), and Keith Promislow (Chair, SFU).

The main objective of this workshop is to provide experience in the use of mathematical modelling as a problem solving tool for graduate students in mathematics and computer science and employees of local industrial companies. The problems came from industial, engineering and biological applications, which were provided by mentors who guided their teams through the entire camp.

Mentors and Projects:

- **Luis Goddyn**, Simon Fraser University, "Computing Two Graph Invariants"
- **Colin Please**, Southampton University, England, "Air Impact Moulding"
- **David Ross**, Eastman Kodak, USA, " A Model of Gelation"
- **Rachel Kuske**, University of Minnesota, "Optimal Policies for Queueing Systems/Networks"

- **Yuexian Li**, University of British Columbia, "Can Electrical Coupling Synchronize Intracellular Calcium Oscillations"

A total of 38 graduate students from 11 universities across Canada, (UBC, UC, UA, Uvic, UT, McGill, UWO, Waterloo, Sherbrook, Manitoba, Queens) were divided into 5 teams, each guided by a mentor from various international Universities and Industries. The programme was quite a success. Those who were around the SFU Math and Stats department surely felt the excitement and energy of the group. Colin Please, a mentor from Southampton University in England and a long-time participant in such events deemed it the best he'd ever been to. Each of the mentors went out of their way to remark on the considerable progress their team had made. Out of the 19 student evaluation forms being collected, 5 rated the workshop as good, 14 rated it as excellent. Almost all the students felt that it was a worthwhile experience and have commented favorably. The students continued on to the PIMS Industrial Problem Soving Workshop (IPS) at Calgary June 1-5. Together with a mix of Faculty from various Canadian and International Universities, they worked in teams on problems straight from industry. The level of energy and preparedness of the graduate students from the MMC was widely remarked. So much so that Chris Budd — a member of the original Oxford Study Group, now the European Study Group and the organizer of a recent meeting in Bath, England – suggested that they might adapt the PIMS plan (mentored graduate student workshop leading into a mixed faculty-grad student industrial session) as the model for their ongoing effort. The European Study Group is preeminent in the field.

PIMS Industrial Problem Solving Workshop (PIMSIPS 2), Calgary, June 1-5, 1998

Organizers: D. Calistrate (Calgary and PIMS), H. Huang (PIMS), M. Paulhus (Calgary and PIMS), R. Westbrook (Calgary).

The format of the workshop were essentially the same as the first workshop in Vancouver. PIMS provided financial assistance to cover the travel expenses of the graduate students attending the three events. The students had a chance to try out their newly acquired skills (in the Modeling Camp) and made a significant contribution to the solutions of these new problems.

The problems investigated by the workshop are:

- **Boeing Corporation:** Year to year, there are wide fluctuations in the demand of airplane orders at Boeing. This causes massive lay-offs and hirings which has very high cost. The problem is to devise a financial strategy to deal with these fluctuations so as to maximize the long term profit of the company.
- **Computer Modeling Group:** Water is often injected into petroleum reservoirs to increase the production of oil from the field. This problem involves modelling the flow of oil and water when the water is injected. This helps to determine the optimal strategy for maximum oil extraction.
- **Geomech Project:** The Geomech project is a joint effort of Petro-Canada, PanCanadian, Talisman and Western Atlas. To profile core underground structures, seismic waves are sent from a source to a receiver. The problem is to determine this profile when the ground density is not constant.
- **ITRES Research Ltd:** Canada is a global leader in the decommissioning of land mines. ITRES is working with the Defense Research Establishment Suffield to develop techniques for visually recognizing trip-wires from images. The problem is to do this in real-time.
- **Powertech Labs:** Multistrand cables are used for overhead electrical lines, ropes, and suspension cables. The maximum sustainable stress on such cables directly impacts, for example, how well electrical lines will perform during an ice storm. Good models have been developed in the case where there is no friction; the goal is to start work in the more realistic case of friction.
- **VisionSmart:** Eggs are prone to make deformities (cracks, pinholes, cage marks etc). It is not practical to manually "candle" the eggs. One suggestion is to shine a narrow laser at the eggs and measure the resulting illumination. The problem is to devise an algorithm that takes this information and determines deformations.

5.2 PIMS Forum on Industrial Mathematics, U. Alberta-U. Victoria, 1999

Following the success of the 1998 industrial forum, this annual forum returns in 1999 and the basic format consists of:

- The *PIMS Graduate Industrial Mathematics Modeling Camp* where graduate students from Canadian universities will come to learn various aspects of high-level techniques for solving industrial mathematics problems. In the second week, the students will participate in the *Third PIMS Industrial Problem Solving Workshop* described below.

Graduate Industrial Mathematical Modeling Camp, U. Alberta, May 24–28, 1999

Coordinator: Gordon Swaters (U. Alberta)

This year, six industrial representatives will come to the modelling camp. Each of them will bring a problem for the students to work on, with the assistance of academic mentors.

Industrial Representatives and Projects:

- **Stefan Bachu**, Alberta Geological Survey, "Geo-Statistical Modelling of Geological Media"
- **Ian Gilles**, Sperry-Sun, "Modeling Uncertainties in Drill-Bore Position"
- **Wayne Grover**, Telecommunications Research Laboratories, "Modeling Telecommunications Network Synchronization"
- **Mike Lipsett**, Syncrude, "Modeling Oil-Sand Extraction"
- **Gordon Leery**, Pulp and Paper Research Centre, "Modeling Print Quality on Paper"
- **Elisa Shabazian**, Lockheed Martin Canada, " Modeling Ship-to-Plane and Plane-to-Ship Tracking"

Over 30 graduate students will be invited to learn techniques for solving industrial mathematics problems. The participants will work in small groups learning the most recent modelling techniques from experts in the field. The mentors will present their problems on the first day, then the students will be split into 6 teams and the mentor will guide their team through to a resolution. Each team will present their results on the final day and a final report detailing the solutions written up by each group will be published.

PIMS Industrial Problem Solving Workshop (PIMSIPS 3), Victoria, May 31 – June 4, 1999

Organizers: C. Bose (Victoria), R. Edwards (Victoria), H. Huang (PIMS), M. Paulhus (Calgary and PIMS).

The format of the workshop will essentially be the same as the previous workshops in Vancouver and Calgary. We are expecting six industrial problems and about one hundred academic participants.

Industrial Participants:

- **Searle**: There are a staggeringly large number of "druglike" chemical compounds which can be made, and the number of unique molecular structures may very well be in the order of 10100. To date, only on the order of 107 compounds have been made and characterized. The main hope in a classification is the existence of a similarity pattern in the chemical structure, called "pharmacophore". Compounds matching the same pharmacophore interact with biological molecules (enzymes, receptors, etc) in a similar fashion, and a classification of these pharmacophores would be considered an enormous breakthrough in drug discovery, providing access to a "key" to every "lock". An immediate question is to estimate the number of these pharmacophores. Mathematically, this is a question about how an object with a small, fixed number of pharmacophoric features fills a cavity, but also an exploration of the minimum set of objects required to display all pharmacophoric elements in all possible geometric arrangements.
- **RSI**: Syncrude operates a large oil-sand mine in northern Alberta and owns several of the world's largest mining excavators. The boom and bucket, which look somewhat like those of a standard construction excavator, are driven by by large hydraulic cylinders operating at up to 30MPa (4350psi).

  Operators of these large machines would benefit from real-time knowedge of (1) the payload in the

bucket, and (2) the digging force at the bucket teeth. In order to be a viable product, this information must be related to the operator without the need to stop the motion of the machine or do anything that would hinder the production. To be useful, the information should be available to the operator with at most 1s latency and should be accurate to within 5% of the payload. Furthermore, a commercial product would be easily applied to any excavator without the need for extensive modelling.

Previous approaches to this problem have followed a traditional robotics/dynamics approach. A dynamic model of the boom and cylinders was developed. Readings from hydraulic pressure sensors and joint angle sensors were fed through the model to determine the payload. However, there are serious limitations of this approach since it is impractical to develop a detailed dynamic model of every machine to which the product would be applied.

The company is interested to know of another approach which can produce the required performance without the need to develop a more detailed dynamic model.

- **Charles Howard & Associates**: The problem is to determine water quality in a water distribution network as a function of time and location. The mathematical problem can be visualized (vaguely) as a system of equations that describe the spatial and temporal transport and dilution of a contaminant injected at a specific location.

  Municipal water distribution systems are unsteady flow, nonlinear networks. In general, the unknowns are: the pressures (after eliminating elevation differences) at each node, the consumption at each node, and the frictional characteristics of each link. The flow in a link is a derived variable that depends on the difference in pressure across the link and the frictional characteristic of the link. In special cases some of the unknowns are known from field measurements, but in general the number of unknowns exceeds the number of equations that can be written (one equation of flow continuity for each node). In practice measurements are expensive so many of the unknowns are assumed to be known.

  The main interest of the company is to determine the distribution of the contaminant volume, ie, its mass and concentration, as a function of time — who gets to drink it, for how long, and when. It is desirable to develop first, a closed form mathematical solution for an approximation to the real problem, and second, a numerical method that could be used to determine the range of applicability of the mathematical method. Then use the mathematical method to solve the inverse problem — given time varying measurements (of concentration and some of the pressures) determine the likely source(s) of the contaminant.

- **Chemex Labs.**: Analytical methods were many elements are determined simultaneously present special difficulties in quality control. The use of individual control charts for each variable (element) is generally not effective due to the combinative aspect of the variation. If there are n elements and the error on each is independent, the probability that all the results will fall within their respective 95(0.95)n. If n = 30 (multi-element analytical packages typically have 25 to 40 elements) this probability is equal to (0.95)30 or 0.2146. In other words there will be one or more elements out of bounds in 78.53of all batches, which on a simplistic interpretation suggests that about two-thirds of all batches will be rejected when nothing is actually wrong with the sample data.

  In practice there will normally be both correlated error, (due to instrument variations that affect all elements or groups of elements) and independent error which is due to variations in the individual element measurement channels. Could the workshop come up with some realistic and efficient control algorithm?

- **Merak**: Foreign production sharing contracts dictate tax rates or payment schedules based on the production from a "ring fence" around a group of wells. Once the tax rate(s) and/or payment(s) are determined, these are applied back to the individual wells. This can cause a variety of interesting mathematical problems when risking or portfolio analysis efforts are made.

- **Enbridge**: The mechanics of batch interfaces is well understood based upon our years of experience in batching fluids. But we have little information that is based upon theory and mathematically modelling. If it were possible to calculate batch interfaces or even to better understand how they happen, grow and stabilize, it may be possible to optimize batch shipments to reduce the product degradation due to batch interface mixing. This would have an economic advantage.

5.3 Industrial Working Seminar Series

The Industrial Working Seminar Series is designed to establish links with the local industry on a continuous basis. Industry representatives are invited to present a mathematical problem that is relevant to his/her company to an appropriately chosen team of mathematical scientists and engineers. A follow-up session is then arranged for further discussion which will provide a basis for continous collaboration. To insure success, the industrial facilitator in BC, **Huax-**

iong Huang identifies suitable problems, contacts the appropriate research groups associated to PIMS and CICSR and keeps both industrialists and academics in constant contact.

- On February 12, 1998, **Murray Margolis**, Manager of **Powerex** dealt with the complex problems of developing "Optimal Trading Strategies for Electrical Power".

  Abstract: Powerex is a wholly owned subsidiary of B.C. Hydro responsible for electricity trading outside the B.C. Hydro System. They are interested in developing a mathematical model to help them set up an optimal trading strategy for the company.

  Electricity is traded daily on the spot market and in addition there is a liquid forward market with seasonal and diurnal price variations. Powerex is an active player in these markets both selling and buying electricity. Under normal conditions Powerex has a long position to sell into the market but the size of this position depends on the reservoir inflows in B.C. and the domestic consumption of electricity.

  In this talk, Mr. Margolis will provide an overview of the problem. The key question is what should an optimal sales and purchase plan be given the uncertainty in weather and the uncertainty in market prices?

- On March 19, 1998, **Marcel Lefrancois**, Research Scientist at **Vortek Industries Ltd.** talked about "The technical challenges of Rapid Thermal Processing in semi-conductors".

  Abstract: The semiconductor industry is rapidly moving towards single wafer processing to achieve the high speeds and small device sizes required. This area is known as Rapid Thermal Processing (RTP) and is the leading technology for the next generation of semiconductor processing equipment. In a rapid thermal processor a single wafer is ramped up at 100^o C per second to temperatures around 1100^o C and then ramped down equally as fast. Vortek Industries Ltd. has built has built a prototype RTP processor and will begin constructing an alpha machine within the next few months. There are some technical challenges in making the alpha RTP processor to achieve wafer uniformity at 1050^o C. Dr. Lefrancois will present a simple RTP tool configuration and discuss the technical problems in meeting the processing requirements.

- On April 15, 1998, **J. Kenna** and **G. James**, Engineers at **Ballard Power Systems** presented an overview of "Evaluating Computational Methods for Fuel Cell Systems".

  Abstract: The mechanism of fluid flow and reactions in a fuel cell system has been successfully defined in basic electrochemistry terms beginning with Sir William Grove. Many of these terms are based on electrochemical principles that require balance equations, diffusion limits, heat transfer, and equilibrium of mass. However, real life effects such as heat and corrosion rates, and mechanical limitations are not included in these idealized equations and have to be mathematically modeled in order to be representative of real fuel cell systems. Fuel cell systems will be discussed in general terms correlating basic electrochemistry with engineering observations. It is these observations that provide the necessary information for implementing successful computational methods. This "observations" versus "calculations" should provide some lively discussions on how to properly model this marvelous electrochemical device.

- On October 6, 1998, **Dr. A. Akhtar**, Director of Strategic Technologies at **Powertech Labs Inc.** gave a seminar on "Acoustic Emission Testing of Continuous Fiber Reinforced Plastic Pressure Vessels".

  Abstract: Continuous Fiber Reinforced Plastic (FRP) pressure vessels are used to store gases under a high pressure for a number of industrial and non-industrial applications. Applications involving transportation dictate that the vessel containing the pressurized gas be designed to remain as light as possible. Examples of such applications are compressed gases on board aircrafts and space crafts, breathing air cylinders used by fire fighters and divers, and, the storage of compressed natural gas (CNG) and compressed hydrogen fuels on Natural Gas Vehicles (NGV) and Hydrogen vehicles respectively. Development of advanced materials with a high strength: mass ratio has contributed significantly towards the objective of weight reduction. However, given a set of materials, the lighter the vessel design the higher are the operating stresses on the walls, which in turn means a shorter life expectancy of the pressure vessel. To ensure safety of operation, the pressure vessel must be inspected periodically. This presentation will provide an overview of the techniques currently used for the periodic inspection of continuous FRP wound pressure vessels, their limitations and the need for the development of acoustic emission test methods. Acoustic emission has the potential to overcome the deficiencies inherent in visual inspection and hydrostatic testing. The latter two techniques are currently in use. A feature of acoustic emission testing which is economically attractive for the on-board fuel storage cylinders is that the pressure vessel need not be removed from the vehicle for inspection. The state of the art of acoustic emission testing of continuous FRP wound vessels will be reviewed. Critical areas of mathematical modelling will be identified for the further development of the acoustic emission test methods.

- On November 17, 1998, **Dr. G. F. Robel**, from the Mathematics and Engineering Analysis Shared Services Group at **The Boeing Company** spoke about "Production Planning under Uncertainty".

  Abstract: The market for large transport airplanes is notoriously volatile. This presents a serious challenge for managers attempting to maximize the long-term market value of an airplane manufacturer. An emerging branch of finanical economics, called "real options," offers a promising approach. In this talk we will present an overview of some of the relevant models from the real options literature. We will also discuss some of the issues which arise when one actually attempts to implement such models, and we will discuss some general conclusions of a qualitative nature which seem to be common across these models.

- On November 27, 1998, **C. Hermansen** and **E. Wang** from **Timberline** presented "Problems in Strategic Forest Planning".

  Abstract: Land allocated to forestry production in Canada is primarily Crown-owned. The vehicle for allocation is usually "long-term area-based tenure", and sometimes "volume quota based tenure". Both types of tenure impose stewardship constraints on the licensor (normally, one of the provincial or territorial governments) and the licensee (normally, a forest products company). These stewardship constraints contain a strategic planning component that demonstrates the long-term impact of forest operations on forest structure, in terms of biodiversity, wildlife habitat requirements, recreation, visual quality objectives, and other landscape management concerns. Forest companies and government agencies charged with forest planning typically maintain comprehensive spatial and attribute databases that model the resources, plans, and administrative units forming the basis of their tenures. These databases are so large and complex and the planning exercises are so comprehensive as to offer a number of interesting areas for basic research in the fields of computational geometry and operations research. This seminar will present an overview of the planning process, a review of the data elements, and a description of a case study demonstrating a number of the temporal and spatial problems arising from the strategic planning process.

- On January 28, 1999, **Dr. O. Walsh**, Vice-President of **FinancialCad** gave a seminar titled "Some Challenging problems in the Area of Mathematical Finance".

  Abstract: There are many mathematical challenges in the world of finance. There is a need to develop better models in areas such as interest rates, energy (particularly electricity) and credit. In these situations, one (or several) of the fundamental market assumptions in the Black-Scholes framework are violated. There is a need to develop efficient and accurate pricing and hedging algorithms for derivatives based on these models. Finally, there is the need to quantify the risk (e.g. value at risk) contained in a portfolio of financial instruments. The challenges are many. We will present an overview with an emphasis placed on the question of realistic and practical market assumptions.

These seminars have resulted in fruitful collaborations between the companies and universities in various format. Many companies became industrial partners of the MITACS network. Others have sponsored PIMS Industrial Problem Solving Workshops and graduate students at PIMS universities.

5.4 PIMS Industrial Facilitators in BC and Alberta

These mathematical scientists are spending time interacting with both university researchers and industrial partners thus facilitating contyacts between industry and persons who have expertise in the various research groups at the five universities. They are also assisting as the administrators and coordinators of industrial workshops. An essential task performed by the facilitators is that of identifying industries that may require mathematical expertise and making initial contact with the research and development personnel of these industries. They have already enabled collaboration of several projects between the academics and the industries. They play a crucial role in soliciting problems from industries for the workshops. The present facilitators are:

- **Dr. Huaxiong Huang**, Director's Office.
- **Marc Paulhus**, University of Calgary site-office.
- **John Vardalas**, University of Alberta site-office.

M. Paulhus and J. Vardalas are responsible for the Calgary and Edmonton areas, respectively. Dr. Huang are responsible for UBC and

SFU. He also coordinates industrial activities between the central office and site offices.

5.5 Industrial Contacts and Partners

Here is an abbreviated list of companies and corresponding contact people who showed interest in collaborating with PIMS.

- Advanis - Michael Williams, President
- Alberta Geological Survey - Stefan Bachu
- Alberta Research Council - Larson Brodner, VP marketing
- Amber Computer Systems
- Ballard Power Systems Inc. - John Kenna, Design Engineer
- Barrodale Computing - Ian Barrodale
- The Boeing Company - Greg Robel, Mathematics and Engineering Analysis, Shared Services Group
- BC Cancer Research Center - Victor Ling, Vice President
- BIOTOOLS - Dr. Wishart, Director
- Canadian Cable Labs - John Madden
- Canadian Energy Research Institute - Anthony Reinsch, VP
- Canadian Institute for Climate Studies - R.J. (Rick) Lee
- Canadian Marconi
- CH & Associates - Charles Howard, President
- Chemex Labs - Michael Legyet
- Computer Modelling Group - F. Meyer, President
- Corel Corporation
- CRA-RTZ
- Creo Corporation
- CREWES (Consortium for Research in Elastic Wave Exploration Seismology)
- Crystar Research Inc. - David Reid
- Diagnostic Engineering Inc. - Thomas Vyskocil, M.Sc., P.Eng. General Manager
- Dynapro
- Eastman Kodak - David Ross
- Enbridge - Don Scott
- Environment Canada - Rob McCandless
- FinancialCad Corp. - David Glassco, CEO
- Firebird - Bill Micklethwaite
- Harley Street Software - Stephan Bulakowski
- Hongkong Bank of Canada
- Hughes Aircraft - J. Joyce
- Husky Oil - Michael Enachescu, Ph.D., D.Ing., P.Geoph. Exploration Specialist
- IBM Canada
- IBM T.J. Watson Research Center - William Pulleyblank
- Imperial Oil(research centre) - Rick Kry, Ph.D., Senior Physicist
- Integrated Flight Systems - L. Hawn, Director
- ISE Research Ltd. - Mae L. Seto, Research Scientist
- Itres Research Ltd. - Avygdor Moise, Vice President
- Lockheed Martin Canada (Montreal) - Elisa Shahbazian
- Lockheed Martin Tactical Defense Systems (Eagan) - Craig Poling
- MacDonald-Dettwiler Associates - Paul Gorton, Director of Engineering
- MacMillan Bloedel Ltd.
- Menex Technologies - Evan West
- Merak - James Henry
- MDSI - Paul Liu
- NALCO Canada Inc. - Gord Harris, Regional Technical Manager
- Northern Telecom - Bill Older
- Novacor - Kamal Botros, P.Eng. Research fellow
- PanCanadian - Roger Coates, Ph.D. Coordinator Technology Group
- Petro Canada - Michael Slawinski, Ph.D. Geophysicist
- Powerex - Murray Margolis, Head Trader
- Powertech Labs Incorporated - Prabha Kundur, President
- Quatronix Media - Pawel Boryniec
- Prestige Telecommunications - Leslie Dejoie
- Pulp and Paper Research Center - Gordon Leery
- Raytheon - Jerry Grammer
- RSI Technologies - David Lokhorst, President
- Searle - Tom Doman
- Shell - David Hanley, Ph.D. Geophysicist
- Shaw Cable - Alex Park
- Simons International Copr. - Les Scovell, Enterprise Development Service Group
- Soundlogic - Combiz Jelveh
- Sperry-Sun - Ian Gilles

- StemCell Technologies - Allen Eaves
- Stentor
- Sun Canada - Bob McCartney, Senior account representative
- Syncrude - Mike Lipsett
- Telecommunications Research Labs - Wayne Grover
- TransAlta Energy Marketing Corp. - Shaun Hatch
- Veritas DGC GeoServices - Scott Cheadle, Ph.D. Director, Research and Development
- Vortek Industries Ltd. - Marcel Lefrancois, Ph.D., Research Scientist
- VGH/Siemens - Anna Celler

5.6 Industrial Postdoctoral Fellowship Programme

Central to the PIMS strategy is the identification of industrial projects that can be tackled by young mathematical scientists. Nine Industrial PDFs were awarded for 1998. See Chapter 2.

5.7 Industrial Workshops and Mini-courses

Mini-courses with topics of interest to both industry and academia are offered to math-users at the universities and the private sector. Their purpose is to disseminate newly developed mathematical tools that can be of use by non-expert maths users. The workshops are more interactive than the mini-courses. They provide a forum where academics and industrial users discuss ideas and problems that arise.

Workshop on Network and Computer Security, Banff, Alberta, May 27 -29, 1998

Organizers: Richard Cleve, University of Calgary

The invention of public-key cryptograpy has resulted in many novel protocols for private communication, message authentication, electronic commerce, etc. For many such protocols, the security is based on ad hoc intuition that is not rigorously verified (and so the protocols may be highly insecure). Mathematical theories of cryptography have been developed, based on concepts such as computational indistinguishability. Based on these theories, protocols exist that, subject to some mathematical assumptions, are probably secure. Frequently, these protocols are significantly more expensive computationally than the less rigorous ones, and, for this reason, they are not widely used in practice. The workshop will include discussion of both theoretical and practical issues, with a view towards bridging them. Participants will include academic researchers as well as people in industries that produce cryptographic products.

The workshop consisted of three days of presentations and informal discussions about cryptography, followed by two additional optional days for informal discussions. The focus was on ways of addressing discrepancies between theoretical and practical perspectives. It is clearly desirable for practitioners to best utilize theoretical results, and for theorists to account for important practical concerns. Fortunately, a number of participants had strong experience in both camps. For example, Josh Benaloh and Daniel Simon of Microsoft, and Alfred Menezes of the University of Waterloo and Certicom. All participants had strong experience in at least one aspect of cryptography, and much of the discussion centered on the theoretical vs. practical issue. For example, a number of problems that were "solved" in the 1980s with protocols that require a "polynomial" number of rounds of interaction are still open if only a small constant number of rounds of interaction are available.

Speakers:

- **Josh Benaloh**, Microsoft, "Group Theory and Structured Hashing"
- **Simon Blake-Wilson**, Certicom, "Two-Party Generation of RSA Keys"
- **Shawn Abbott**, Rainbow Technologies, "Practical Issues in Commercial Cryptographic Hardware"
- **Anna Johnston**, Sandia, "Protocols for International Treaty Verification"
- **Alfred Menezes**, U of Waterloo, "Key Agreement Protocols"
- **Michele Mosca**, U of Oxford, "Quantum Computation and its Potential Impact on Classical Cryp-

tography"

- **Dan Simon**, Microsoft, "Finding Collisions on a One-Way Street: Can Secure Hash Functions be Based on General Assumptions?"
- **Moti Yung**, CertCo/Columbia.

The abstracts of the talks are accessible from the workshop web site
http://www.cpsc.ucalgary.ca/ pims/

Workshop on Coding Theory, Cryptography, and Computer Security, Lethbridge, August 3-7, 1998

Organizers: H. Kharaghani and W. H. Holzmann, University of Lethbridge.

Combinatorial Matrix Theory is an emerging branch of combinatorics. Applications include Coding Theory, Cryptography, and recently Computer Security. Naturally there is much interest and demand in computer security as more use is being made of computer networks and the Internet. Recent developments in Hadamard matrices has indicated that the theory has great potential for use in computer security. The main objective of this workshop was to bring together a leading group of researchers to promote the research in western Canada in this area.

The workshop was held on the campus of the University of Lethbridge, in Lethbridge, Alberta. There were 34 participants, which included renowned mathematicians and computer scientists from around the world. There were four participants from industry and four graduate students. Morning sessions were devoted to the instructional talks on Coding Theory given by Professor Vladimir Tonchev, on Cryptography given by Professor Charles Colbourn, and on Computer Security, given by Professor Jennifer Seberry. Invited talks and contributed papers were presented in the afternoon sessions. Altogether there were 7 one hour invited talks and 10 half hour talks in those sessions.

Speakers:

- **Charlie Colbourn**, University of Vermont, USA,
- **Jennifer Seberry**, University of Wollongong, Australia,
- **Vladimir Tonchev**, Michigan Technological University, USA,
- **Robert Craigen**, Fresno Pacific University, USA,
- **Warwick de Launey**, CCR-LJ, Institute for Defense Analysis, USA,
- **Kathy Horadam**, Royal Melbourne Institute of Technology, Australia,
- **G. B. Khosrovshahi**, Institute for Studies in Theoretical Physics and Mathematics, Iran,
- **P. Shiue**, University of Nevada Las Vegas, USA,
- **Mieko Yamada**, Kanazawa University, Japan.

The workshop was co-sponsored by the University of Lethbridge, the Royal Bank Financial Group, VeriSign Inc. and the Bank of Montreal.

The abstract of the talks and related information are available on the web at
http://www.cs.uleth.ca/ccc98.

CACR Information Security Workshop, SFU at Harbour Centre, June 9, 1999

Organizer: The University of Waterloo's Centre for Applied Cryptographic Research, CACR

The series has been established to provide a highly focused content and programme covering topics of interest to the potential and sponsors' customers, and employees. The targeted attendee has a solid background in public-key technology/information security, and in deploying information security solutions and other applications. This individual understands the issues in this area and attends the workshop in order to gain the exposure to different approaches.

This workshop focuses on specific issues such as authority certificates, on and off-line certificate validation, certificate revocation and related topics, in particular, investigating current and proposed protocols, processes and technology that will help provide solutions to meet short to long-term requirements in these areas.

Invited Speakers Include: Bill Lattin (Certicom), Joe Kovara (CyberSafe), Michael Myers (VeriSign), Peter Williams (ValiCert), Mary Horrigan (Scotiabank), Michael Versace (Bank of Boston), Jonathan Callas (Kroll-O'Gara, ISG)

This workshop is co-sponsored by Certicom Corporation, Mondex International, Mastercard International, MITACS, and Pitney Bowes.

PIMS Summer School in Industrial Fluid Dynamics, University of Alberta, August 7-20, 1999

Organizers: B.R. Sutherland and T.B. Moodie, University of Alberta.

This summer school offers an enriched learning environment in which the theoretical, experimental and computational aspects of fluid dynamics are synthesized. Participants will attend a comprehensive series of lectures, and will be given hands-on experience performing and analyzing experiments in the Environmental and Industrial Fluid Dynamics Laboratory. In addition, they will run numerical simulations using research-level codes. Topics will include fluid dynamics fundamentals, industrial and environmental flows, geophysical fluid dynamics, turbulence modelling and computational fluid dynamics.

Invited Speakers

G. Lawrence, University of British Columbia
P. Morrison, University of Texas at Austin
W. R. Peltier, University of Toronto

Core Lecturers

A. B. G. Bush, Earth & Atmos. Sciences, UA
J. C. Bowman, Math Sciences, UA
P. D. Minev, Math Sciences, UA
T. B. Moodie, Math Sciences, UA
B. R. Sutherland, Math Sciences, UA
G. E. Swaters, Math Sciences, UA

Chapter 6

PIMS Math. Education Activities: 1998–99

PIMS initiates educational activities at all levels, from grades K-12 to university level. In the schools, these activities include for example involvement in teacher training and retraining through workshops for teachers, workshops for students and their parents, sponsorship and initiation of math fairs and clubs, as well as training camps for mathematics competitions. In universities, PIMS is sponsoring national conferences for undergraduate students and is also initiating a major drive to increase the total numbers of graduate students studying in the mathematical sciences at PIMS universities.

6.1 Initiatives for K-12 Students

PIMS is continuing to bring members of the scientific community and the community at large closer together through an increasing number and variety of events. Events have continued during the 1998/99 academic year in both BC and Alberta.

Activities for Elementary Schools

Alternative Mathematics Education Events

This programme consists of regular evenings on "Alternative Math Education" where Faculty and Staff from the PIMS Universities present "fun" methods for teaching math and computer science to children (and adults!) using games and art. Typically included in the presentations are soap bubble demonstrations, constellations as 2D networks, geometry and paper, the Set Game, Computer Science Unplugged and MegaMath, a binomial probability experiment using pennies, and exciting geometrical models from straws and paper.

The events in 1998 and a recent one in 1999 are

- At **Cloverdale Elementary School**, on March 3, 1998.
- At **Colwood Elementary School**, on November 5, 1998.
- At **Rogers Elementary School**, on February 25, 1999.

Amongst regular people who participated in the event are: **Kathy Beveridge**, Victoria; **Charlie Burton**, UVic; **Malgorzata Dubiel**, SFU; **Mike Fellows**, UVic (Computer Science Unplugged, Mega-Math), **Denton Hewgill**, **Reinhard Illner** and **David Leeming** (UVic).

Mathematics Unplugged

This is a Student Mathematics Conference. Elementary students attend a full day math conference, including workshops chosen by themselves following a keynote address. Workshops are presented by all levels of instructors, including university professors, school district per-

sonnel, school staff, parents and Science World staff. Just as Eric Clapton and Rod Stewart "unplugged" their music, PIMS will provide students with an opportunity to see that mathematics can be an exciting and enjoyable topic, and that it is all around them! The goals for the conference are to:

- Show students that Mathematics is in all aspects of everyday life
- Show that there is a lot of Mathematics in other subject areas
- Offer as many exciting math workshops as possible
- Show students that Mathematics is more than what they can find in school textbooks
- Keep the number of students in workshops small (20 or less), therefore lots of hands-on experiences.
- Utilize expertise from the community
- The first one was held on May 30th, 1997 in Westwood Elementary in Coquitlam with a keynote address given by **Dr. Kathy Heinrich** (SFU). Over 350 students and 15 teachers did participate.
- A second one was held on April 23, 1998 again in Westwood Elementary in Coquitlam with a keynote address given by **Dr. Maria Klawe** (UBC).
- A third one was held on April 30, 1999 again in Westwood Elementary in Coquitlam with a keynote address given by **Dr. Kathy Heinrich** (SFU)

All events were organized by **Pamela Hagen** (Westwood Elementary). We expect to continue this programme on an annual basis, attracting students from other schools and also multiply this initiative to other schools.

Math Fairs and SMART Club

Following a highly successful Mathematics fair at **Meadowlark Shopping Mall** in November, 1997, we have received requests from several schools to help organize similar events. Schools throughout the area will be invited to participate with PIMS organizing judging and prizes; it is envisaged that students in mathematics education at the University of Alberta will work closely with the school children in the preparation of small group projects.

An annual PIMS Math Fair at the University of Alberta or the Edmonton Space Science Centre is also planned, with elementary, junior and senior high school divisions. Each participating school will submit one group project, which will be on display on the day of the Math Fair. Registration and set-up will be conducted in the morning, and after lunch, the Math Fair will be open to the public. A panel of judges will award prizes. There will also be supplement lectures for the students as well as for the public.

The SMART Club is essentially Saturday afternoons activities, recreation and tutorials in mathematics that have been very successful since their inception in 1981. these are held in Edmonton under the careful management of Dr. Andy Liu. Parents drive their children long distances to attend these classes. PIMS will "franchise" this idea to multiply these clubs throughout Alberta.

Activities with High School Students

The PIMS education panel is organizing a number of events aimed at high school students. Here we describe two such events, highlighting the breadth of activities that PIMS offers.

International Mathematics Olympiad Training Camp, Calgary, June 30 – July 13, 1998

Organizer: B. Sands (U. Calgary)

The International Mathematical Olympiad (IMO) is a mathematics competition for high school students held each summer. High school students from 70 or 80 countries from around the world compete annually with each country sending one team of up to six students. Canada has been entering a team in this competition since 1981 and usually finishes in the top 20 countries.

This year the IMO was in Taiwan, and the Mathematics Department of the University of Calgary in collabioration with PIMS hosted the national summer training camp. This was the first time in quite a few years that a training camp was held in Alberta (it was in B. C. in 1990 and 1994).

6.2 Initiatives with K-12 Teachers

With new mathematics curricula being developed across Western Canada, PIMS scientists have found considerable demand for teacher training and retraining. Teachers are also interested in exchanging ideas with academics.

PIMS Conferences on Changing the Culture

Organized by M. Dubiel (SFU), P. Hagen (Westwood Elementary), K. Heinrich (SFU), B. McAskill (BC Ministry of Education), E. Perkins (UBC), these conferences are intended to forge closer ties between the mathematics community, mathematics teachers and the industry. Erasing barriers between these communities and looking for common ground is an essential step in any attempts at changing the mathematics culture.

Changing the Culture I, SFU at Harbour center, Feb. 20–21, 1998

Plenary Talk: **Peter Taylor** (Queens University): "Post-Impressionism and Math Education".

Public Talk: **Bruce Shawyer** (Memorial University): "The Olympiad Spirit — stimulating student interest and improving student performance through mathematics competitions".

Small Group Discussions:

- **Group 1:** Who are the mathematicians? Who does mathematics? What is a teacher of mathematics? What exactly is mathematics?
- **Group 2:** How to balance the traditional with what's changing? What value is in the traditional? Are we going from one extreme to another?
- **Group 3:** Traditional values versus new expectations: how do we see the new culture?

Panel Discussions

- **Panel 1:** What is happening in the math classroom Tom O'Shea (Education, Simon Fraser University) David Ryeburn (Mathematics, Simon Fraser University) Malcolm Sneddon (Ministry of Education, Skills and Training)
- **Panel 2:** DOING mathematics with students Pamela Hagen (Westwood Elementary School) Nathalie Sinclair (Simon Fraser, Island Pacific School) George Bluman (University of British Columbia)

Changing the Culture II, SFU at Harbour Center, Feb. 19-20, 1999

The second annual conference again brought together mathematics researchers, educators and school teachers from all levels to work towards narrowing the gap between mathematicians and teachers of mathematics, and between those who enjoy mathematics and those who think they don't.

The conference in 1999 opened with a plenary talk by Leah Keshet (UBC) – The Study of Living Things: So, What's Math Got To Do With It?? – showing an abundance of mathematical models in biology. The first day closed with a public lecture by Doris Schattschneider (Moravian College, Pennsylvania) – Ingenious mathematical amateurs: M.C. Escher (artist) and Marjorie Rice (homemaker) – describing how two talented and persevering amateurs made substantial contributions to the field.

The pivotal event on Friday was a 1 and 3/4 hour panel discussion on the question: To what extent is an appreciation of mathematics possible without mathematical training? The three very different positions taken by the panelists Kanwal Neel (BCAMT), Mike Fellows (UVic), and Jeremy Quastel (U of T) elicited a lively exchange with the audience – including the moderator, Klaus Hoechsmann.

In the morning, three discussion groups had been formed to ponder the questions: (1) Can biology be a major context for math classes? (2) How do visualization and logic interact in mathematics? (3) Is applied math easier than pure math? They were led by the organizers of the conference: Malgorzata Dubiel (SFU), Pamela Hagen (Westwood Elementary), and Klaus Hoechsmann (UBC), with the assistance of Bob Camfeld, Djun Kim, and Natasa Siroti, respectively. After the panel discussion, they met again and extended their deliberations to the additional common question: (4) Can people be taught to like mathematics?

Saturday's opening talk was given by Adrian Lewis (University of Waterloo) – Would Pythagoras have liked Mozart? – showing, among other things, that one of Mozart's last quartets begins with a musical square root of two. It was followed by a panel, moderated by Malgorzata Dubiel, which examined the question: Mathematics and the Arts: where do they meet? Owen Underhill (SFU) spoke about music – in particular, his opera Star

Catalogues – Doris Schattschneider explained her mathematics course for Fine Arts Majors, and Ron Coleborn (BCAMT) enlivened his plea for a thinned out curriculum by his considerable acting talent.

CMS-PIMS Education Session on Mathematics and the Internet, Dec. 14-15, 1998

Organizers: June Lester, Nathalie Sinclair and Malgorzata Dubiel (SFU)

Speakers:

- **Bill Casselman,** UBC on: *Colour, animation, interaction*
- **Loki Jorgensen,** SFU on: *The CMS journals online*
- **Stan Devitt,** Waterloo Maple on: *MathML support for defining notation*
- **Nick Jackiw,** KCP Technologies on: *JavaSketchpad*
- **Robert Miner,** WebEQ on: *Putting math on the Web*
- **Stan Devitt,** Waterloo Maple on: *Relationship between OpenMath and MathML*

6.3 Initiatives for Undergraduate Students

PIMS Graduate Weekends

The purpose of the weekends is to let the students know about many of the very exciting research projects and initiatives taking place in the Mathematical Sciences departments.

PIMS Graduate Weekend I, UBC, SFU, February 19-21, 1998

Organizers: L. Keshet, A. Gupta, K. Promislow.

PIMS hosted its first annual graduate weekend on February 19 to 21 on the campuses of the University of British Columbia and Simon Fraser University. About 45 of the top fourth year undergraduates in the mathematical sciences from across Canada were invited to Vancouver to learn more about graduate opportunities at the five PIMS universities.

Students had a chance to tour the facilities of both UBC and SFU and meet faculty and graduate students in one-on-one sessions. Various receptions, lunches, and a banquet dinner gave students a chance to talk with faculty and graduate students in a variety of informal settings. Representatives of the University of Victoria, the University of Alberta, and the University of Calgary were also on hand to talk about their graduate programmes with the students.

The event was very well received by the students. Many were not aware that graduate students are treated as "junior colleagues" by faculty and work closely with their supervisor. For all the students, finding out about the large number of programmes run by PIMS geared to graduate students was a major revelation and clearly something that will influence their choice of grad studies. Quite a few students indicated that they will now seriously consider graduate studies, and especially, graduate studies in Western Canada.

PIMS Graduate Weekend II, UA-UC, January 19–24, 1999

Organizers: G. Swaters, R. Wesbrook.

The 1999 PIMS Graduate Weekend was held at the campuses of the University of Calgary and the University of Alberta on January 19–24, 1999. Students from across Canada were flown into Calgary on the 19th, where they attended a number of information sessions and met with University of Calgary faculty members on the following day. They had the opportunity to listen to four different sessions describing various research opportunities in the mathematical and statistical sciences. On the 21st, they were bused to Edmonton to visit the University of Alberta, where they attended another 12 sessions describing research opportunities in Algebra, Geometry & Topology, Classical & Functional Analysis, ODEs & PDEs, Fluid Dynamics, Computational Sciences, Statistics and Mathematical Biology, Finance, and Physics. In addition to the University of Alberta and University of Calgary

speakers, there were presentations by representatives from Simon Fraser University and the University of British Columbia.

Social activities included a welcoming reception held at their hotel on the evening of the students' arrival in Edmonton. A luncheon was also provided the following day for all of the attendees, as well as the current graduate students in the Department of Math. Sciences, University of Alberta. The attendees very much enjoyed the chance to speak on an informal basis with a group of current graduate students. The attendees also were treated to a formal banquet at the University of Alberta Faculty Club, which was attended by Dean R. Peter, Faculty of Science, University of Alberta.

Canadian Undergraduate Mathematics Conference, UBC, July 9-12, 1998

Organizers: Michael Kozdron, UBC Mathematics Undergraduate, Chairman of the Organizing Committee, Alex Alami, UBC Mathematics Undergraduate, Vice President, Evagelos Agapios, UBC Mathematics Undergraduate, Secretary, David Wees, UBC Mathematics Undergraduate, Treasurer, Dr. Sandy Rutherford and Dr. Lon Rosen, UBC Department of Mathematics, Faculty Advisors to the Conference.

The Canadian Undergraduate Mathematics Conference of 1998 was sponsored by PIMS. This conference provides a forum for the exchange of ideas among undergraduate mathematics students from all Canadian universities and gives students the chance to express themselves in a way which is not readily available in the day-to-day curriculum. Participants present talks on either their current research projects or on any other mathematics-related topic. These presentations give participants insight into current research of students as well as give them new ideas in order to improve their own work. Guest speakers are invited with the intention of exposing students to the current "hot areas" of research in the mathematical community.

Participants:

The participants in the CUMC are undergraduates pursuing degrees in the various mathematical sciences - pure and applied mathematics, statistics and actuarial sciences - and students who have just completed such degrees. The conference attracts students of the highest calibre, enthusiastic and active in their departments. About 110 students participated in the conference and of these about 30 gave presentations. In addition, five guest speakers, including three from local universities and two keynote speakers from out-of-town, were invited to address the conference.

The Canadian Undergraduate Mathematics Conference is especially beneficial for undergraduates because it allows them to meet other students interested in mathematics. The conference also provides students with the opportunity to see applications of the material they study in the classroom and, hopefully, will encourage students to pursue further study in mathematics.

Invited Speakers:

- **Ivar Ekeland**, Université Paris-Dauphine on *Celestial mechanics and celestial motion*
- **Hervé Moulin**, Purdue University on *Mathematics in the social sciences*
- **Leah Keshet**, UBC on *Math Biology*
- **David Austin**, UBC on *Knot theory*
- **Peter Borwein**, SFU on *Pi*.

6.4 Initiatives for Graduate Students

Graduate Industrial Math Modeling Camps

First annual Graduate Industrial Math Modeling Camp, SFU, May 25-29, 1998

Organizers: K. Promislow and A. Gupta (SFU), H. Huang (PIMS).

Second annual Graduate Industrial Math Modeling Camp, U. Alberta, May 24-28, 1999

Organizer: G. Swaters (U. Alberta).

PIMS Summer School in Fluid Dynamics, University of Alberta, August 7-20, 1999

(See Chapter 5: PIMS Industrial Initiatives).

Chapter 7

Technology-based Mathematics Initiatives in 1998–99

The Pacific Institute is working to provide a useful, comprehensive collection of tools for teaching, learning and promoting mathematics and disseminating research with computers. Examples of such resources will include on-line interactive courses and modules, reusable software components, research and computational tools and an interactive electronic mathematics journal. The target user group includes mathematicians, scientists, educators (mostly secondary and post-secondary) and students of the mathematical sciences.

Here are some of the projects which illustrate our committment to these goals.

7.1 The UBC Sun SITE Project

Coordinator: Bill Casselman (UBC)

The UBC Mathematics Department has been designated by Sun Microsystems as a Sun SITE and PIMS has elected to co-sponsor it by contributing the (half-time) salary for the administrator of the SITE. The SITE is one of about eight in North America, among them some of the most useful and popular Internet sites for University users. The official goal of Sun's project is for each SITE to operate as "a library, a publishing house, a distribution center and a technology showcase." In this vein, the aims of the UBC SITE include the introduction of more professional standards in high-tech electronic mathematics publication as well as involving local groups in a collaborative effort to produce high quality Internet material for use in the Mathematics community at large. The location of the UBC Sun SITE is: **sunsite.ubc.ca**

The SITE is currently being financially supported by PIMS. It began with a large hardware donation from Sun Microsystems, to be used for maintaining the SITE, developing software for it, and experimenting with various means of utilizing it.

The designation by Sun Microsystems is almost certainly recognition of the early role of the Mathematics Department at UBC in using Java for both course work and research in Mathematics.

New advances in programming languages—for example, Java, Postscript and HTML—together with the interconnectivity of the World Wide Web are providing mathematicians with unique opportunities to express their ideas in novel ways and to a wider audience. Although the role of the Internet in explaining mathematics is already beyond easy comprehension, the Sun SITE at UBC hopes to make a small start in raising standards. We hope to find a role as a moderator in the development of this new medium by providing a forum for the electronic publication of suitable work and by providing guidance through technical assistance and by example.

As one of roughly fifty Sun SITEs worldwide, the UBC project is the only Sun SITE based at a mathematics department and serving primarily mathematical content. Because the SITEs are authorized by Sun and are known to have generally high standards, these sites have a tremendous number of users. For this reason, this project can expect to enjoy a rather high profile on the World Wide Web.

7.2 The Electronic Mathematician

This is an electronic, refereed mathematics journal which will focus on the communication of mathematics through ways not allowed in traditional paper publishing. This distinguishes it from nearly all other electronic mathematics journals, which act largely as a replacement for paper but otherwise are not technologically innovative.

To be considered for publication in this new journal, a submission must have an essential electronic component, such as interactivity, graphics or hypertext, which could not be adequately conveyed through a conventional paper journal. A somewhat similar journal, Comunications in Visual Mathematics, is edited by Thomas Banchoff and Davide Cervone and sponsored by the Mathematical Association of America and the NSF. But in the near future one can expect the importance of such "totally electronic" journals to grow rapidly.

At this stage, the important thing for such a journal to possess is technical expertise, and in this—with our extensive use of Java and network administartion—we may be better situated than the CVM. Running a journal like this is, in fact, much like running a small software shop. In addition to editing the journal in the usual way, the Electronic Mathematician staff expect to provide technical assistance to authors as well as build sample submissions which demonstrate the power of the new medium. Technical assitance will include a collection of short articles and presentations of techniques in Java programming and mathematical graphics design.

7.3 The Digital Mathematics Archive

This is a digital collection of mathematical sources including papers, letters, manuscripts, and computer rendered images and computations. Many of today's source documents are much more ephemeral than the documents of the previous century. This archive will allow some of this material to be preserved while giving it a wide distribution.

1. At the moment the main item in the Archive is a growing collection of the professional correspondence of Professor Robert P. Langlands of the Institute for Advanced Study, once himself an undergraduate at UBC, as well as a selection of previously unpublished work and published work now out of print. One of the first documents in this collection is a 17 page hand-written letter to Andre Weil, written while Langlands was at Princeton University, outlining what quickly became known as 'the Langlands conjectures'. The SITE presents large-format digitized images of the original letters together with .dvi and .pdf format transcriptions. It is hoped that this project will eventually include other work of a similar nature.

2. A second example is **a digital version of Oliver Byrne's 1847 graphical edition of Euclid's Elements**. This will be reproduced at the highest quality affordable, in contrast to many casual digital mathematical images on the Internet. It is hoped that it will serve as a nucleus for local educational projects concerned with Euclid and geometry.

7.4 Distributed Access Resource Infrastructure (DARI), SFU

Coordinators: J. Borwein (SFU), C. Laflamme, R. Wittig (Calgary)

This is a joint project between the Pacific Institute, the Centre for Experimental and Constructive Mathematics (CECM) and the High-Performance Computing Network (HPCnet). Its main goal is to facilitate the transfer of mathematical resources and technology selected groups within the PIMS and HPCnet community to an on-line Java-based environment for wide-spread dissemination and exposure. Those projects that will significantly benefit from network accessibility will be reframed in an on-line context using state-of-the-art network delivery technologies.

For that, a network analyst/programmer position was created in the Polymath Development Group (PDG) at the CECM. The programmer supported this reframing process, interacting between the selected client sites and the PDG, generating visible examples of on-line tools, interfaces and resources.

A typical implementation provides an interactive tool which can appear on a Web page allowing a user immediate access to the algorithm, database, resource or information that otherwise would not be available. In particular, this project helped transform several major in-house experimental math tools and other computational projects, producing distributed network Java front ends that allow authorized users anywhere in the world to access and use them. Examples include *NumberView*, a tool for visually investigating patterns in the decimal expansions of numbers, *EZ-face Calculator*, an interface for the evaluation of Euler sums, and *Code Converter*, a service for converting Maple code to FORTRAN and C.

7.5 The KnotPlot Project

Coordinator: Bob Scharein, UBC

This project builds on the research described in the author's doctoral dissertation *Interactive Topological Drawing*. In particular, one goal is to make the large amount of experimental data obtained during the thesis research widely available to the mathematical community at large via the World Wide Web (WWW). A second goal is to make the software used to obtain the data (principally KnotPlot) available for academics and other researchers, or for artists and people with a general interest in knots.

Knot theory on the World Wide Web

The web site will provide mathematicians with a comprehensive encyclopaedia of information on cataloged knots and links. Initially, this will be limited to the nearly 400 knots and links found in Appendix C of Rolfsen's book on *Knots and Links*. In addition to providing images of each knot (in several different formats), the database will also contain topological information of use to knot theorists. In particular the following topological and geometric data will be available:

- Crossing number, stick number, unknotting number
- Signature, Arf invariant, knot group
- Fourier coefficients
- Closed braid description(s)
- Conway number
- Alexander, Jones, HOMFLY, Kauffman and other polynomials
- Known symmetries along with a catalogue of interesting symmetric presentations (both for smooth version and minimal stick version)
- Sufficient invariants to distinguish from any other knot in the Rolfsen catalogue
- Vertex data giving an instance of the knot type

Knot Theory

Aim is to provide an on-line, high-quality, and interactive instructional tool for learning knot theory and its relation to other areas of mathematics and science. This overlaps with the goals of *The Knot Project*.

- Accessible to wide audience
- Suitable in some degree for instructional purposes from K through 12 and beginning university level
- Activity areas
  - draw your own knot and obtain output (note this overlaps with the functionality of the knot)
  - learn about tying simple knots with real rope (this will include animations of knot tying)
- Knot art — learn appreciation for mathematics through beautiful images of knots (this is partly accomplished already by the KnotPlot Site)

Chapter 8

MITACS: A Network of Centers of Excellence in the Mathematical Sciences

Mathematics of Information Technology and Complex Systems (MITACS) is one of the three new Networks of Centers of Excellence (NCE) created in 1998. The MITACS NCE is a joint venture of the three Canadian mathematical sciences institutes: the Centre de Recherches Mathématiques, the Fields Institute in Mathematical Sciences and the Pacific Institute for the Mathematical Sciences. MITACS will harness mathematical power for the benefit of the Canadian economy. The network brings together more than 150 researchers at 22 Canadian universities with more than 70 Canadian industrial, medical, and financial organizations. The network comprises 21 projects addressing problems in five sectors of the Canadian economy.

The creation of the MITACS network provides an exceptional opportunity for the mathematical sciences community to develop a large scale systematic programme for research, HQP training and the development of partnerships with key business, industrial and health care sectors across the country.

In the following, we describe briefly the rationale behind the network which is structured around the three mathematical sciences research institutes and the networks of universities affiliated with them.

8.1 Introduction to MITACS

MITACS was created to bring together leading researchers in the mathematical sciences to focus on the problems of mathematical modelling and management of large scale complex systems and the mathematics of information technology. There are three main goals of the MITACS network:

- To develop new mathematical tools for problems in areas where mathematics plays a central role. Such areas can range from molecular biology to resource management to computer networks.
- To bring together a national network of leading mathematical scientists from universities and industries across Canada.
- To provide new opportunities for outstanding young mathematical scientists to develop their skills in those areas that will enhance the quality of life in Canada.

Projects in the MITACS network are targeted towards the MITACS user community. Members of the community are drawn from business and industry, the non-profit sector, the health care sector, the educational sector, and the government sector. All research projects in MITACS

will either develop new mathematical ideas or make use of mathematical tools and techniques to work towards solutions to problems of interest to the MITACS partner user community. MITACS researchers will conduct basic and applied research in three identified themes. However, because of the unifying nature of mathematics, there may be close connections between projects in different themes. The five main themes are:

- **The Mathematics of the Trading and Finance Sector:** Topics of research in this theme include: Risk measurement and models for nonstandard commodity markets; Default risk: value-at-risk and credit risk; Interest rate models; Portfolio allocation models; and Pricing of derivatives (parametric and nonparametric). The shared mathematical methodologies include: Stochastic Modeling, Information reduction in high-dimensional statistical models; Inference in parametric and nonparametric models; Monte Carlo, numerical and calibration methods.

- **The Mathematics of the BioMedical Sector:** The projects in this theme are concerned with issues of human health and disease: Understanding of physiological and disease mechanisms; Understanding of the mechanisms of drug therapy and other interventions; Development of accurate and cost-effective methods of diagnosis; Design of individual and population interventions, such as drug and gene therapies, vaccines and public health programmes prevention, diagnosis, remediation and control of disease. They also share common mathematical methodologies: Development of mathematical, statistical, and computer models for complex non-linear systems; application of techniques to detect patterns in high-dimensional, temporal and spatial data; use of biologically relevant computer simulation, mathematical approximation, and asymptotics need for methods of statistical inference to interpreting variability.

- **The Mathematics of the Information Technology Sector:** The objective of this theme is to identify and resolve strategically important mathematical problems that are central to the development, organization, and utilization of integrated systems. This includes the next generation of telecommunication networks, concurrent and real-time reactive systems, new tools to extract knowledge from high dimensional data sets, and new algorithms and software designs for symbolic analysis. Methodologies include: stochastic modelling, regression analysis, algebraic computation, constructive logics, and others.

- **The Mathematics of the Commercial Industrial Sector:** As commercial processes become more complicated, large scale optimization packages are essential for industrial resource allocation. This theme consists of specific projects with the collaboration of numerous industrial partners dealing with problems such as personnel planning and scheduling, natural resources management and the development of a dynamic transportationinfrastructure for industrial just-in-time delivery systems. Techniques from many disciplines, from operations research to computer science and statistics, will be used to solve these problems. One strategy will be to develop decomposition techniques for the large problem formulation domain to reduce complexity and to explore new techniques for developing better approximation algorithms, drawing on research in discrete optimization and algorithm design.

- **The Mathematics of the Manufacturing Sector:** Even though this theme deals with more traditional applications of the mathematical sciences, it was included in MITACS Phase 1 for two reasons: First, it is needed in order to maintain and strengthen Canada's leading edge in some emerging industries like in building cellular automata using semiconductor nano-structures and in developing ef-

ficient fuel cells by Ballard Powersystems. Secondly, it can also be considered as a supporting theme as the teams involved in its projects (e.g., the broad based proposal "Mathematical Modeling and Scientific Computation") consist of well established applied mathematicians, mathematical modelers and computational scientists who have the skills to solve industrial problems from a variety of different fields and who will assist and support many other MITACS projects.

8.2 MITACS Research Programme

Challenges of mathematical modelling and the management of complex and large-scale systems arise across the scientific, industrial, financial and medical sectors. Finding new tools to meet these challenges is intrinsically collaborative work requiring a mix of mathematical, statistical, computational methodologies. This is an area in which Canada is well-positioned to exploit because of the world-class group of researchers already in place. An important part of the task is to develop linkages between the various groups currently undertaking this research individually, and create a whole greater than its parts by working in tandem. The primary objective of MITACS is to achieve this by forming an interdisciplinary network of mathematicians, statisticians, communications engineers and computer scientists, organized under project leaders, to focus on the interconnected themes of modelling and management of large scale and complex systems and the mathematics of information technology. These two basic research themes will be integrated into a number of projects which will focus on either the specific problems arising in one of the major user sectors, or one of the major methodologies common to these user sectors. A number of core methodological challenges run through all these projects: deterministic and stochastic modelling of complex systems, data analysis in high dimensions, statistical estimation methods, optimization, mathematical algorithms and technology-based tools. In most cases the problems arising in the user sectors require the combined application of several if not all of these methodologies. There is an exceptional opportunity for cross-fertilization and synergy by having these research groups share resources, expertise and complementary perspectives on the set of rapidly developing tools. The Network will bring together researchers from industry and universities across the country in multidisciplinary and multi-sector research teams, as well as arrange for joint workshops and exchanges between these teams. This networking at two levels will create the critical mass and synergy necessary to place Canada at the leading edge of these developments. Major concentration areas will be:

- **Inference from High Dimensional Data**: Massive amounts of data, frequently high dimensional, arise in a broad variety of applications including astrophysical models, telecommunications applications, finance and medical research. Researchers in all of these application areas currently face fundamental mathematical problems of inference in order to extract useful information from these data sets. Mathematical and empirical results suggest that models based on multilayer neural networks that learn to project the data in a low dimensional space provide an effective method to deal with such data. A team of statisticians and computer scientists will concentrate on developing, improving, and applying algorithms for making inference from high-dimensional data in applications that interest our industrial partners in the banking, telecommunications and public utilities sectors. The project will take advantage of the existing links with industrial partners developed at the CIRANO Research Centre around more applied research projects.

- **Biomedical Modelling and Biostatistics**: In the medical sciences, dynamical modelling and statistical tools (including inference high dimensional data) are essential to deal with the overwhelming complexity of biological systems and the mas-

sive data generated by the Human Genome Project. With the prospect of sequencing all 100,000 human genes within the next few years, genetic epidemiology and molecular medicine have emerged as new research fields. The availability of this new data has led to a shift in attention in genetics to include diseases such as cancer and cardiovascular disease which depend on many different factors. The objectives of the multidisciplinary research teams will be to develop mathematical models, data analytical tools and flexible computational techniques to address problems in medical science arising in the study of multifactorial disease, the cellular biology of cystic fibrosis, physiology, the nervous system, and medical imaging.

- **Risk Management**: The area of risk management in the financial services sector has been transformed in recent years by the development of the sophisticated financial derivatives, hedging strategies and risk metrics initiated from the celebrated Black-Scholes formula (for which M. Scholes and R. Merton were awarded the 1997 Nobel prize in economics). A research team will work with a number of financial institutions to tackle emerging problems in risk management, such as the estimation of the volatility of price processes, credit risk management, asset allocation and term structure models - problems which will be addressed using new tools of stochastic analysis, and methodologies developed in the data analysis and optimization projects.

- **Modelling and Management of Computer and Communications Networks**: The growing complexity of high-speed networks makes the incorporation of advanced theoretical techniques imperative for achieving efficient designs. The project team will work with high tech companies to develop a combination of analytical, semi-analytical and simulation methodologies for system design, bandwidth allocation, and optimization of performance in high-speed computing and communications environments. In collaboration with Nortel, CITO and other receptors, project teams will investigate the impact of metastability and hysteresis on performance of circuit-switched networks with dynamic routing, and develop tools to predict loss of information and delays in high-speed multimedia traffic using the theory of large deviations and self-similar processes.

- **Techniques for Resource Optimization**: As the industrial process becomes more complicated, large scale optimization packages are essential for industrial resource allocation. Techniques from many disciplines, from operations research to computer science and statistics, will be used to solve these problems. One strategy will be to develop decomposition techniques for the large problem formulation domain to reduce complexity and to explore new techniques for developing better approximation algorithms, drawing on research in discrete optimization and algorithm design. Projects with the collaboration of IBM and other industrial partners are being developed on problems such as personnel planning and scheduling, natural resources management and the development of a dynamic transportation infrastructure for industrial just-in-time delivery systems.

- **Mathematical Algorithms and Technology based Mathematical Tools**: Mathematical software tools have become the primary research resource across the mathematical sciences. Notably, through the software package Maple, Canada is a world-leader in this field. The success of these tools has relied on (literally) hundreds of individual developments of two varieties: mathematical development of new and faster algorithms and software design improvements, set against the critical issue of designing user compatible interfaces. The burgeoning industry in-

volved with building on-line interactive (often JAVA based) mathematics interfaces shares these problems. Research projects in co-operation with Waterloo Maple and other receptors will address a number of critical issues, such as increasing the speed of symbolic algebra packages, the difficult mathematical problems involved in automatic simplification of complex formula and expression recognition.

- **Secure Communications**: Cryptography: Secure encryption methods are critical for maintaining confidentiality of medical data, banking transaction and communications via ATM networks. This problem has been altered dramatically through the development of public-key cryptography. Canadians are pioneering the development and commercialization of new encoding algorithms. In particular, Canadian elliptic-curve algorithms are applied to public-key encryption algorithms, make number factoring and the derivation of logarithms more difficult, and therefore more secure making possible the commercial application of digital signatures and certificates. A team of computer scientists and number theorists in collaboration with CACR and Certicom will investigate these and other emerging issues which are fundamental to cryptography in an environment of widespread availability of increasing computing power.

- **Mathematical Modeling in Fuel-cell Technology**: The main problem is the understanding of mass and heat transfer on and across the proton exchange membrane. Humid hydrogen and oxygen gas mixtures are driven along cross hatched channels on either side. Hydrogen permeates the membrane and reacts with the oxygen, releasing heat and electrons. Of vital interest is the density of hydrogen and oxygen on either side and particularly the development of "hot-spots" on the membrane which aversely affect its longevity. Basic questions must be answered about the magnitude of convective versus diffusive cooling of the membrane, membrane oscillation due to interaction with the flow, reactant diffusion within the membrane, possible development of recirculation areas in the flows with the associated effects of reactant depletion and local heat build-up, as well as water condensation within the flow channels, possibly within turbulent flow regimes. While several of these problems are amenable to conventional numerical methods, many require sophisticated computational methods and detailed analytical studies, and could develop into large-scale computations.

8.3 Highly Qualified Personnel

As indicated above, a major limiting factor in the growth of the knowledge-based industries is the supply of highly trained personnel. Mathematical scientists with postgraduate degrees are currently being hired in increasing numbers in the financial, cryptography and software industries. An important mission of MITACS will be to provide new opportunities for outstanding young mathematical scientists to develop their skills in these fields and to provide the world class activity that will keep them in Canada. This programme, to be developed in cooperation with existing graduate programmes, will supplement the Canadian university system by providing training not feasible at individual universities or departments. These training opportunities, scholarships and fellowships will be open on a competitive basis to all qualified mathematical science students from across Canada.

The training programme for both graduate students and postdoctoral fellows will consist of:

- industrial problem solving workshops, where interdisciplinary student teams will work on real-world problems posed by the industrial partners;

- scholarships and subsidies to attend annual meetings, regional meetings, and Network

workshops;

- increased opportunities for working in multidisciplinary research teams; an internship programme with the Network?s industrial partners;
- and joint post-doctoral appointments with the research teams and industrial partners.

The student training programmes will be developed to encourage a beneficial interaction between the research and the business environments, training personnel that will not only posses sound research and technical skills, but also an understanding of Canadian business needs and practices. In addition to increasing the number of graduate students and encouraging them to stay in Canada, MITACS will provide significant value to Canadian companies by giving them the opportunity to identify and evaluate potential employees through the internship and industrial postdoctoral fellowship programmes.

8.4 Networking and Partnerships

MITACS will be built upon the three existing Canadian institutes for research in mathematical sciences, Centre de Recherches Mathématiques in Montreal (CRM), the Fields Institute for Research in Mathematical Sciences in Toronto (FI), and the Pacific Institute for Research in Mathematical Sciences (PIMS) in Alberta and British Columbia. Each of the institutes have a number of associated universities. Together, they link the mathematical science departments at the major Canadian research universities. The Network will add to these linkages by integrating the Institutes' smaller networks in a unified research programme, and will serve as a catalyst, bringing together academic researchers together with industrial researchers, blurring the demarcation between industry and academia. Bringing these regional networks of mathematicians, statisticians and computer scientists and their industrial partners together in a network of centres of excellence will create an exceptional opportunity for synergy. Network is the possibility of resource sharing. The three institutes will each contribute some basic infrastructure and staff for the Network and, by working together, do this in a highly cost-effective way. The Network will capitalize on the administrative expertise of the institutes, which can organize workshops, bring in international experts as part of the core and targeted research programmes, and provide meeting and office space for network participants. Networking these regional centres together creates the added potential for making linkages between researchers in one region with industrial partners in another region. In order to develop collaborations among the three regional centres, a programme of joint annual meetings, and exchanges of members of the research groups will be initiated.

8.5 Current MITACS Projects

There are 21 current MITACS projects across the country in five themes. It is expected that new projects will form, while the existing projects may expand to include more faculty members and industrial partners. Here is a list of the current projects:

Mathematics of Financial Risk Management

- **Leader:** Dr. L. Seco, Director, U. Toronto
- **Members:** P. Boyle (Wadsworth Professor of Finance and Director of the Centre for Advanced Studies in Finance, University of Waterloo) M. Crouchy (Senior Vice President, Global Analytics, Market Risk Management Division, CIBC) G. Dionne (Risk Management Chair, Finance Department, HEC, Montreal) J. Im (Senior Manager, Global Analytics, Risk Management, CIBC) K. Jackson (CS, University of Toronto) D. McLeish (Stats, University of Waterloo) G. Nudelman (General Manager, Glocal Analytics, Risk Management, CIBC) E. Prisman (Nigel Martin Chair of Finance, Schulich School of Business, York University) L. Seco (Math, University of Toronto)
- **Industrial Affiliates:** Algorithmics, CIBC, Bank of Nova Scotia, Refco Futures
- **Problem Statement:** Pricing of derivatives, hedging, risk metrics, etc. have become standard

tools for market risk management and for the creation of many new financial instruments. They have also stimulated a new area of mathematical research activity. This field is rapidly moving to a higher level of sophistication and methodological challenge. For example, one of the important recent developments faced by the banks is the need to quantify credit risk, to have capital requirements based on credit risk and possibly to trade credit risk in the form of credit derivatives. This creates the need to develop a sound basis and methodology for credit derivatives. In view of the long time horizon involved, completely new methodological challenges arise in their evaluation. This example illustrates the type of problem for which the basic research has not yet resolved the central questions but is one which financial institutions expect will emerge as an important issue within the next year or so.

Portfolio theory has been the central object of study in mathematical finance since the work of Nobel Laureate Markovitz in the 50's. This provides financial firms with investment strategies that archive their risk/reward goals. When approaching portfolio theory from the risk management viewpoint, fundamental differences appear which force us to adopt novel ideas. The basic fact underlying this is that one now needs to deal with the portfolio of whole institutions, for which traditional theories become impractical. The way out of this goes through portfolio compression. Roughly speaking, this is the theory that allows one to replace huge portfolios by smaller ones. In practice, it is the particular risk-issue that determines the compression methodology to adopt. The proposed research is an investigation of compression issues in all contemporary situations.

Simulation, Estimation and Inference in Financial Models for Risk Management and Derivative Pricing

- **Leader:** J. Dufour (Economics, Head CRDE)
- **Members:** J. Detemple (Chair in Finance, McGill University) R. Garcia (Economics, Université de Montréal) C. Gouriiroux (Head of Finance Lab, CREST) N. Meddahi (Math & Finance, Université de Montréal) B. Perron (Econometrics and Finance, Université de Montréal) E. Renault (Head of CREST) R. Roy (Math & Stats, Université de Montréal)
- **Industrial Affiliates:** Banque Nationale, Hydro Quebec, CRDE
- **Problem Statement:** This project addresses the problem of providing risk management offices with new financial models and econometric tools for better trading strategies. The project involves three general themes: portfolio allocation in continuous time models and nonparametric pricing of derivatives, information reduction in high-dimension statistical models, and inference methods in parametric and nonparametric models.

Modelling, Trading and Risk in the Market

- **Leader:** U. Haussmann (Math, UBC)
- **Members:** L. Bates (Management, University of Calgary) M. Barlow (Math, UBC) M. Buchko (Trader, Powerex Corporation) D. Druce (Research Scientist, BC Hydro) D. Glassco (Chairman & CEO, Financial CAD Corporation) C. Gui (Math, UBC) A. Lari-Lavassani (Math, University of Calgary) J. Liu (Math, UBC) N. Ghoussoub (Math, UBC) M. Margolis (Head Trader, Powerex Corporation) A. Peirce (Math, UBC) E. Perkins (Math, UBC) G. Sick (Finance, University of Calgary) J. Walsh (Math, UBC) O. Walsh (Director of Financial Engineering, Fiancial CAD Corporation)
- **Industrial Affiliates:** Financial CAD, Powerex Corporation, BC Hydro, Transalta
- **Problem Statement:** Traders must make educated decisions about when to buy and sell in financial markets and commodity markets. For non-standard commodities, such as energy (electricity, natural gas) or time on long-distance communication channels (where it is a "use it or lose it" situation), this requires modelling and forecasting supply, demand and price. For the more developed financial market case, issues to be addressed are risk in various forms: value at risk, credit risk and portfolio risk, as well as modelling the term structure of forward prices and interest rates.

Statistical Modeling and Analysis of Complex Traits in Human Populations

- **Leader:** S. Bull (Public Health Sciences, University of Toronto)
- **Members:** D. Andrews (Stats, University of Toronto) M. Corey (Paediatrics, Public Health Sciences; Hospital for Sick Children Research Institute, University of Toronto) G. Darlington (Public Health Sciences; Cancer Care Ontario, University of Toronto) M. Escobar (Public Health Sciences, University of Toronto) C. Field (Math, Stats & CS, Dalhousie University) P. Hooper (Math, University of Alberta) K. Morgan (Human Genetics, Medicine; Montreal General Hospital Research Institute, McGill University) B. Smith (Math, Stats & CS, Dalhousie University) D. Tritchler (Medical Biophysics and Public Health Sciences; Ontario Cancer Institute, University of Toronto)

- **Industrial Affiliates:** Ellipsis Biotherapeutics, Mt. Sinai Hospital, Ontario Cancer Institute, Montreal General Hospital
- **Problem Statement:** Complex traits, including disease and disabilities, that vary in human populations are determined by multiple genetic and environmental factors that interact with one another in complicated, often non-linear ways. The nature and complexity of these interactions depend on characteristics of the population as well as characteristics of the individual and the family. With continuing advances in molecular biologic technology and the prospect of a complete reference sequence of the entire human genome in the near future, biomedical investigators face an explosion in data that are highly dimensional and have complex structure. Appropriate analysis is required to direct scientific energy and resources into feasible and effective medical interventions.

Modeling and Analysis of Networks of Neurons: Understanding Their Role in Information Processing and Control

- **Leader:** S. Campbell (Math, U. of Waterloo)
- **Members:** M. Hulliger (AHFMR Medical Scientist, Clinical Neuroscience, Faculty of Medicine, University of Calgary) W. Langford (Math & Stats, University of Guelph) M. Mackey (Physiology, Physics, and Math; Director of Centre for Nonlinear Dynamics in Physiology and Medicine) J. Milton (Adjunct Professor, Department of Physiology and Neurology, McGill University; and Director, Epilepsy Centre, University of Chicago) P. van den Driessche (Math, University of Victoria) J. Wu (Math & Stats, York University) X. Zou (Math & Stats, Memorial University of Newfoundland)
- **Problem Statement:** The spatio-temporal dynamics of large numbers of neurons in the central nervous system lie at the basis of phenomena such as memory, cognition, pattern recognition, the control of movement, and a wide range of nervous system diseases including epilepsy, aphasia and movement disorders, e.g. ataxia and Parkinsonian dyskinesia. However, the way in which the necessary information is encoded in the complicated dynamics of these networks is poorly understood.

Control of Atrial Fibrillation

- **Leader:** L. Glass (Physiology, McGill University)
- **Members:** J. Bélair (Math, Université de Montréal) M. Courtemanche (Math, McGill University) M. Dubuc (Clinical cardiac electrophysiologist, McGill University) R. Kapral (Chemistry, University of Toronto) R. Mehra (Leader of atrial fibrillation research, Medtronic) S. Nattel (Director of Research, McGill University) A. Shrier (Chair of Physiology, McGill University) M. Talajic (Clinical cardiac electrophysiologist, McGill University)
- **Industrial Affiliates:** CyroCath Technologies, Medtronic
- **Problem Statement:** Reentrant tachycardias are a serious medical problem in which the frequency of the heartbeat is set by the time it takes for an excitation to travel in a circuitous pathway. This time is usually shorter than the normal period of the heartbeat. Consequently reentrant tachycardias are abnormally rapid rhythms (tachycardias). The reentrant circuit can be confined to a localized region of the heart or involve several different regions, but similar theoretical principles apply. The objective is to develop novel methods to control atrial fibrillation. In atrial fibrillation, the upper chambers of the heart (the atria) are activated by complex meandering rotating waves. The lower chambers of the heart (the ventricles) are activated in irregular fashion by activation waves that successfully traverse the atrioventricular node, the only electrical connection between the atria and ventricles. Development of a method for control will have an important impact on health. Because of the likelihood that novel control methods will be carried out only by the development of new technology, there will be important financial gains for those who develop and implement the new technologies. Our goal is to develop new technology. However, since atrial fibrillation is a multi-faceted disorder that arises in a large number of different settings, it is unlikely that there will be a single approach that will be successful in all cases. Therefore, we will simultaneously explore several different approaches. We believe that successful clinical applications will need to combine these approaches.

Mathematical and Computer Modeling of Epidemics with Public Health Applications

- **Leader:** J. Hsieh (Biostatistics & Public Health Sciences, University of Toronto)
- **Members:** P. Corey (Public Health Sciences, University of Toronto) B. Di Stefano (President, Nuptek System) A. Lawniczak (Math & Stats, University of Guelph) S. Mitter (Directeur du Service Biostatique, Gestion des Données Pharmaco-Economique, Affaires Cliniques et Medicales, Pasteur Merieux Connaught) R. Remis (Public Health Sciences, University of Toronto) P. van den Driessche (Math, University of Victoria)
- **Industrial Affiliates:** Connaught Labs
- **Problem Statement:** Epidemics appear to have killed more people than any other medical cause.

Diseases such as tuberculosis and AIDS have a disastrous impact. The nonlinear nature of transmission of infectious disease leads to challenging mathematical problems. As well, incomplete epidemic data and population heterogeneity require innovative mathematical, statistical and computer simulation techniques. The ultimate goal is to develop models for the design of intervention and control programmes such as optimal vaccination programmes.

Biomedical Models of Cellular and Physiological Systems in Health and Disease

- **Leader:** L. Keshet, Department of Mathematics, University of British Columbia
- **Members:** Dr. G. de Vries (Math, UA) Dr. D. Finegood (Kinesiology, SFU) Dr. R. Miura (Math, UBC) Dr. J. Piret (Biotech Lab, Chemical Eng, Bioresource Eng, UBC) Dr. D. Schwarz (Research Director, Dept of Surgery, UBC) Dr. C. Shaw (Opthalmology, UBC) Dr. Y. Xian Li (Math, UBC)
- **Industrial Affiliates:** Inex, In Computro, Kinetek, Precision Biochemicals, Stem Cell Tech, TherExcel
- **Problem Statement:** We investigate the use of mathematical models of cellular processes to improve diagnosis, prevention or remediation, and design of treatments for disease, leading to innovative drugs and diagnostic kits for neurodegenerative disease, neuronal dynamic disorders, and hormonal dysfunction.

Inference from High-Dimensional Data

- **Leader:** Y. Bengio (CS & OR, Université de Montréal)
- **Members:** H. Chipman (Stats and Actuarial Science, Waterloo) J. Lawless (Stats and Actuarial Science, Waterloo) C. Liger (Math & Stats, Université de Montréal) R. Tibshirani (Stats, Preventive Medicine, University of Toronto)
- **Industrial Affiliates:** GM, MicroCell
- **Problem Statement:** Machine learning and nonparametric multivariate function estimation provide automatic methods to infer a function of the input variables from a set of data, used to predict the output variables. In applications such as those that interest our industrial partners, too many input variables (that all may be relevant) are available. Inference from such data sets is harder, and many learning algorithms and statistical models generalize rather poorly to new data (generalization to out-of-sample data is the real objective). This mathematical problem is also known as the "curse of dimensionality".

  It has been recognized in the last few years by many corporations that they possess an almost untapped source of information to improve themselves: the huge amount of computerized data that they are collecting on their processes and their customers. Unfortunately, for the reason above, traditional tools in statistical multivariate data analysis and machine learning algorithms are not well suited to extracting information from such high-dimensional data sets. Recent research in this area has emerged as a field in itself, sometimes called "data mining", with new journals and conferences (the International Conference on Knowledge Discovery and Data Mining) and journals. Results in this area are important not only for our sponsors but for many Canadian corporations that wish to take advantage of their databases. For example, much more efficient database marketing is obtained based on such analyses.

Symbolic Analysis

- **Leader:** P. Borwein (Math & Stats, SFU)
- **Members:** F. Bergeron (Math, Université de Québec à Montréal) J. Borwein (Math & Stats, SFU) R. Corless (Math, UWO) S. Devitt (Waterloo Maple Inc) D. Jeffrey (Math, UWO) L. Jorgenson (Math & Stats, SFU) M. Lamoureux (Math & Stats, University of Calgary) M. Monagan (Math & Stats, SFU) J. Stafford (Math, UWO) S. Watt (Math, UWO)
- **Industrial Affiliates:** CRC, Math Resources, Sun Microsystems, Waterloo Maple
- **Problem Statement:** The principal problem is to incorporate analytic objects into symbolic computation environments (specifically Maple) with the same computational fluency as is presently available for algebraic problems. How, for example, does one address continuity and all the geometric issues this entails? Current systems break down at this point. Some specific components are:

  Analytic algorithms including algorithms for exact integration, identity and inequality verification, automatic differentiation, differentiation of non-smooth function, exact series evaluation, asymptotics.

  Analysis of functions represented by formulae and programmes including handling of domain information, relations and inequalities, and automatic differentiation of programmes.

  Assimilation of large scale data including incorporation of tables of integrals, transforms and the like in an interactive way.

  Communication having the various components talk to each other: LaTeX to Maple to XML/MathML for example. Analysis of functions represented by formulae and programmes.

Reverse symbolic engineering to determine what calculation led to an answer.

Mathematical Methods for Modeling, Verification and Testing in Information Technology

- **Leader:** B. Kapron (CS, University of Victoria)
- **Members:** M. Cheng (CS, University of Victoria) J. Delgrande (CS, SFU) M. Kouritzin (Math, U. of Alberta) B. Older (NORTEL) P. Panangaden (CS, McGill)
- **Industrial Affiliates:** Nortel
- **Problem Statement:** Reactive systems are primarily involved in interaction with other systems or an external environment. In real-time systems these interactions take place in real time. Hybrid systems manifest both continuous and discrete behaviour. Examples include operating systems, network protocols and air traffic control systems. Modeling and analysis of system performance and its relationship with system behaviour and reliability is a serious problem.

Prediction in Interacting Systems

- **Leader:** M. Kouritzin (Math, University of Alberta)
- **Members:** D. Blount (Math, Arizona State University), J. Bowman (Math, University of Alberta), D. Dawson (Director, Fields), R. Eliott (Math, University of Alberta), S. Feng (Math, McMaster), K. Fleischmann (Math, University of Alberta), E. Gombay (Math, University of Alberta), P. Greenwood (Math, University of British Columbia), A. Heunis (Engineering, Waterloo), A. Jouan (Research and Development, Lockheed Martin-Montial), B. Kapron (CS, University of Victoria), B. Leininger (Lockheed Martin Tactical Defence Systems at Eagan), R. Mahler (Lockheed Martin Tactical Defence Systems at Eagan), E. Perkins (Math, UBC), C. Poling (Lockheed Martin Tactical Defence Systems at Eagan), N. Prasad (Math, University of Alberta), B. Remillard (Université du Québec à Trois Rivihres), B. Schmuland (Math, University of Alberta), E. Shahbazian (Lockheed Martin-Montréal), S. Shen (Math, University of Alberta), Y. Shu Wong (Math, University of Alberta),
- **Industrial Affiliates:** Advantis, Lockheed Martin Canada, Lockheed Martin Tactical Defence
- **Problem Statement:** Prediction and tracking strategies for aircraft above a busy airport is a major problem. These planes, whose exact number and position are unknown, or "random" will interact to avoid collisions. Local weather variations between the ground and each craft, the effect of a craft's wake on the other planes, and additional factors constitute a "random environment" for such an interacting stochastic system and severely complicate the modelling, tracking, and prediction procedures.

Complex Adaptive Networks for Computing and Communication

- **Leader:** M. Devetsikiotis (Systems and Computer Eng, Carleton)
- **Members:** M. Barlow (Math, UBC), A. Borodin (CS, University of Toronto), A. Bose (Systems and Computer Eng, Carleton), M. Csorgo (Math, Carleton), W. Cunningham (C & O, Waterloo), D. Dawson (Director, Fields), T. Drwiega (Nortel Advanced Technologies), J. Edmonds (CS, York), P. Glynn (Systems and Computer Eng, Carleton) G. Goddard (Nortel Advanced Technologies), G. Kesidis (Waterloo), T. Kostantopoulos (University of Texas at Austin), D. Krizanc (CS, Carleton), I. Lambadaris (Math, Carleton), N. Madras (York), A. Pelc (CS, Université du Québec à Hull), J. Rao (Stats, Carleton), B. Richter (Math, Carleton), N. Santoro (CS, Carleton), R. Srinivasan (Math, University of Saskatchewan),
- **Industrial Affiliates:** Nortel
- **Problem Statement:** Prompted by envisioned advances in telecommunication technology, the study of computing and communication networks has become an important research activity in computer science and communication engineering. The growing complexity of high-speed networks makes the incorporation of advanced mathematical methodology important for achieving efficient designs.

Elliptic Curve Cryptography and Agebraic Combinatorics

- **Leader:** S. Vanstone (Pitney Bowes Industrial Chair in Cryptography, Waterloo)
- **Members:** A. Agnew (EE, Waterloo), D. De Caen (Queens'), C. Godsil (C & O, Waterloo), I. Goulden (C & O, Waterloo), A. Hasan (EE, Waterloo), D. Jackson (C & O, Waterloo), B. Martin (University of Winnipeg), A. Menezes (C & O, Waterloo), D. Stinson (Certicom Industrial Chair in Cryptography, Waterloo), J. van Rees (University of Manitoba), H. Williams (Certicom)
- **Industrial Affiliates:** Certicom
- **Problem Statement:** Information is recognized by many organization as an important asset. Few businesses could function effectively without the ability to rely to some extent on information as a resource. Information security is concerned with

providing assurances about the secrecy and authenticity of data, and is of strategic importance to today's world of open networks and electronic data. Cryptography has enormous potential for providing information security services in real-world applications. From basic credit card authorization to wireless transactions, cryptography provides security and enhances the efficiency of electronic commerce. A recent breakthrough is the digital signature that provides verifiable validation for electronic communications.

Elliptic curve cryptography appears to be especially attractive for implementation in computationally-constrained environments such as smart cards, pagers, cellular phone and PDA's. The focus of this project is to carry out research on the security and implementation of elliptic curve cryptosystems, as well as their applications in electronic commerce, internet security, telecommunications and wireless communications.

Facility location optimization

- **Leader:** B. Bhattacharya, School of Computer Sciences, Simon Fraser University
- **Members:** P. Bose (CS, Carleton University) J. M. Keil (CS, University of Saskatchewan) D. Kirkpatrick (CS, UBC) T. Shermer (CS, SFU) J. Snoeyink (CS, UBC) G. Toussaint (CS, McGill University)
- **Industrial Affiliates:** MDSI,

  Metafact Technologies
- **Problem Statement:** Facility location problems involve locating one or more service facilities to optimally supply a given set of demand destinations. The facilities and destinations may be vertices in a graph or points in the real plane with the Euclidean or other metric.

  Two common objectives are MINMAX, which seeks to minimize the maximum weighted distance from the demand destinations to their nearest source facility, and MINSUM, which seeks to minimize the sum of the weighted distances to the nearest source facility. For p facilities the MINMAX problems are often called p- problems and the MINSUM problems the p-median problems. When p is large, the general problems are almost always NP-hard.

The Mathematics of Resource Allocation and Scheduling

- **Leader:** P. Hell (CS and Math & Stats, SFU)
- **Members:** B. Alspach (Math & Stats, SFU) J.M. Bourjolly (Concordia) W. Cunningham (C & O, University of Waterloo) L. Goddyn (Math & Stats, SFU) A. Gupta (CS, SFU) L. Hafer (CS, SFU) R. Krishnamurti (CS, SFU) W. Pulleyblank (Director, Mathematical Sciences, T.J.Watson Labs, IBM) M. Queyranne (Manag. Sci, UBC)
- **Industrial Affiliates:** Amber Systems, HA Simons, IBM, Prestige Telecommunications
- **Problem Statement:** Modern industrial operations require the efficient deployment of resources. This has resulted in extensive work on the theory of scheduling, with a focus on optimal or near-optimal long-term planning. However, the ability to react quickly to unexpected events is also essential. This underlying theme recurs through disparate applications from multiprocessing in computer systems, to material handling and transportation. Careful advance planning is essential, but even slight deviations in the consumption or availability of resources can precipitate a crisis.

  The efficient scheduling of a fleet of trucks for just-in-time delivery might require planning with a monthly time horizon, but when a driver calls in sick, the schedule must be modified immediately. The schedule for the shutdown, overhaul, and startup sequence for preventative maintenance of a pulp line might be planned weeks in advance, but the sudden breakdown of a machine requires a response within minutes. Remaining competitive means tuning the operation so there is little margin for error. This type of long term planning is very difficult and integer-linear programming methodologies are often used to obtain optimal long term schedules. However, these techniques are much too time-consuming for the quick adaptations of schedules. A large corporation can sometimes handle such problems by allowing some slack but for a small company employing excess resources can represent a significant cost. When an emergency occurs, fast heuristics are needed to modify long range plans in an intelligent manner in the time available.

Planning, optimization and design of Mobile Communication Systems; Models and algorithms for reasoning under uncertainty

- **Leader:** B. Jaumard (GERAD & Math and Industrial Engineering, École Polytechnique de Montréal)
- **Members:** P. Caines (McGill) C. Charalambous (McGill) M. Delfour (CRM, Université de Montréal) P. Hansen, (HEC, Université de Montréal) R. Malhame (École Polytechnique de Montréal)
- **Industrial Affiliates:** Bell Mobility, Centre de Recherches pour la Defence
- **Problem Statement:** This project will consider two problems.

1. Mobile communication The accelerating demand for spectrum resources in large urban areas has been, is and will remain a problem in mobile voice and data communications. Mobile communications systems are growing rapidly, new spectrum bands have been opened and highly efficient new technologies have been introduced. Yet there is an upper limit to usable spectrum and to technological capabilities. This presents many challenges to researchers in mathematics, operations research and electrical engineering.
2. Reasoning with incomplete data Real-time processing of large amounts of uncertain and possibly incomplete data, which is of paramount importance in many industrial and defense contexts. This processing is crucial to the system, called Maritime Command and Control (C2), by which commanders of naval warships can plan, direct, control, and monitor operations for which they are responsible in order to defend their ship and fulfill their mission. Developing appropriate methodologies is an important problem.

Probabilistic Mathematical Models for Complex Industrial Systems

- **Leader:** M. Puterman (Commerce, UBC)
- **Members:** D. Atkins (Commerce, UBC) J. Bookbinder (Waterloo) C. Boutilier (CS, UBC) H. Chen (Commerce, UBC) M. Gendreau (Université de Montréal) B. Lamond (Université Laval) J. McGill (Queen's University) D. Lawson (Commerce, UBC)
- **Industrial Affiliates:** BC Tel, Canadian Airlines, Workers Compensation Board of BC
- **Problem Statement:** Canadian industry faces a wide range of challenging operational problems that it must solve to remain competitive and productive in the 21st century. These problems require mathematical models that can account for both the complexity and uncertainty in production, inventory and information systems. This project seeks to develop and implement new methods for managing complex inventory, production, logistics and service systems. The focus is the development of models for performance analysis and control based on stochastic process and optimal stochastic control methodology. Specific areas of investigation will be drawn from industrial projects with Bureau for Research on Applications of Management Science and Statistics (BRAMSS) and Centre for Operations Excellence (COE) partners and affiliates including job shop production planning and control (Avcorp Industries), call centre performance and staffing (BC Tel, BC Tel Mobility and The Worker's Compensation Board), parts and retail inventory management (BC Tel and Canadian Airlines) and vehicle routing (Court Services Branch, BC Attorney General's Ministry).

Large Flight Attendant Personalized Scheduling System

- **Leader:** F. Sourmis (École Polytechnique)
- **Members:** J. Desrosiers (École des HEC) P. Hansen (École des HEC) T. McCormick (Mngmt Sci, UBC) O. Marcotte (Université de Québec à Montréal) M. Queyranne (Mngmt Sci, UBC) G. Savard (École Polytechnique)
- **Industrial Affiliates:** AdOpt.
- **Problem Statement:** A. GENCOL is a general software package applicable to a large class of resource management problems. The problem is to increase its capacity by an order of magnitude and make it applicable to much more complex problems. These problems are varied and the paths covering the tasks can represent, for example, vehicle routes, or sequences of tasks to be carried out by an employee or a machine. Specifically the problem of scheduling flight attendants will be addressed.

Building and Modeling Cellular Automata using Semiconductor Nanostructure

- **Leader:** H. Ruda (University of Toronto)
- **Members:** M. Allmang (University of Western Ontario) A. Lawniczak (University of Guelph) T. Lookman (University of Western Ontario) Z-H. Lu (NRC) A. Venetsanopoulos (University of Toronto) B. Yacobi (Energenius Inc)
- **Industrial Affiliates:**
  Energenius Inc, Nuptek
- **Problem Statement:** Although there have been a few of reports of modelling quantum cellular automata, these models have been restricted to relatively simple one dimensional systems of only a few cells long. In addition there have been no practical devices of this sort fabricated. However, even from this limited work it is clear that such systems offer unique advantages for information processing. The proposed extension of models to two dimensional networks and building and characterizing real systems should provide ground rules for building real computational systems.

Mathematical Modeling and Scientific Computation

- **Leader:** B. Wetton (Math, UBC)

- **Members:** R. Choksi (Math & Stats, SFU) H. Huang (Industrial Math Coordinator, PIMS) M.C. Kropinski (Math & Stats, SFU) A. Peirce (Math, UBC) K. Promislow (Math & Stats, SFU) B. Russell (Math & Stats, SFU) B. Seymour (Math, UBC) M. Ward (Math, UBC) R. Westbrook (Math & Stats, University of Calgary)
- **Industrial Affiliates:** Ballard Powersystems, Powertech Labs
- **Problem Statement:** Our purpose is to foster the development of industrial mathematics in Canada. We will meet with representatives from the industry and identify questions that can be answered with the mathematical modelling and scientific computing expertise we have. Graduate students and post-docs will be involved with the problems we find. We will have the challenge of extending the techniques we know to real-world problems and our industrial partners will gain insights that would be impossible without the power of modern applied mathematical techniques.

  Mathematical modelling is needed to translate the important elements of complicated physical problems into forms that are amenable to numerical methods. We have identified two industrial problems which require such expertise to understand the relevant physical processes. One is from Powertech Labs, which is working with BC Hydro to develop technology for nondestructive testing using acoustic emission measurments. The other is from Ballard Power Systems, a world leader in fuel cell technology.

  Acoustic emission measurement problem. Continuous fiber over-wrapped vessels with a metallic or a polymeric liner are used for the high pressure (200 - 240 bar) gaseous fuel storage on natural gas vehicles (NGV) and hydrogen vehicles. To minimize the mass of the vessel, these vessels are designed such that the ratio of burst pressure to the operating pressure may be as low as 2, a figure substantially lower than those used with ASME design vessels. To ensure safety, periodic inspection of the vessels is desirable. Acoustic emission is an attractive option, since in-situ retesting of the cylinder while on-board the vehicle, would eliminate costs associated with the removal and re-installation of the vessel.

  Mathematical modelling and experiments suggest that conventional approaches used for acoustic emission testing are not applicable to the metal lined FRP hoop-wrapped vessel.

  Fuel cell problem. The first problem is the understanding of mass and heat transfer on and across the proton exchange membrane. Humid hydrogen and oxygen gas mixtures are driven along cross hatched channels on either side. Hydrogen permeates the membrane and reacts with the oxygen, releasing heat and electrons. Of vital interest is the density of hydrogen and oxygen on either side and particularly the development of "hot-spots" on the membrane which aversely affect its longevity. Basic questions must be answered about the magnitude of convective versus diffusive cooling of the membrane, membrane oscillation due to interaction with the flow, reactant diffusion within the membrane, possible development of recirculation areas in the flows with the associated effects of reactant depletion and local heat build-up, as well as water condensation within the flow channels, possibly within turbulent flow regimes.

  While several of these problems are amenable to conventional numerical methods, many require sophisticated computational methods and detailed analytical studies, and could develop into large-scale computations.

Chapter 9

Financial Report

During the fiscal year 1998/1999, PIMS has received interim funding from NSERC, the Provinces of Alberta and British Columbia and the 5 founding universities in BC and Alberta. The Fields Institute and the CRM also contributed to the support of PIMS' activities. The PIMS fiscal year runs from April 1 of the current year to March 31 of the subsequent year. In this section we outline the PIMS budget for the fiscal year 1998–1999.

PIMS has supported its activities on interim funding from:

- The five founding PIMS institutions (SFU, U. of Alberta, UBC, U. of Calgary, U. of Victoria) and the affiliated Institutions (U. of Lethbridge and U. of Northern British Columbia).
- The Government of British Columbia through the Science and Information Technology Agency
- The Government of Alberta through the Alberta Science and Research Authority.
- The Government of Canada through the Natural Sciences and Engineering Research Council.
- The Fields Institute in Toronto and the Centre de Recherches Mathématiques in Montréal.

9.1 Income Sources

	1998–1999	
	Cash	**In-kind**
NSERC	**$200,000**	
Alberta	**$110,000**	
BC	**$97,500**	
Fields Institute	**$65,000**	
CRM	**$50,000**	
Universities		
SFU	$55,000	$70,000
UA	$45,000	$70,000
UBC	$95,000	$190,000
UC	$40,000	$70,000
UVic	$40,000	$70,000
U Lethbridge	$5,000	
Total	**$280,000**	**$470,000**
Total	**$802,500**	**$470,000**

Income for 1998–1999

Notes: Each founding university makes an annual cash contribution equivalent to one full time faculty position at the respective university. Also, scientific personnel are released under the PIMS research fellowship programme to provide the scientific leadership in the institute. PIMS is only required to make up the course buy-out for these individuals. The universities also make considerable in-kind contributions through office space at the five campuses and computer labs.

SFU: SFU made an annual cash contribution of $55,000 and released the Deputy Director half-time from other duties. In-kind support of offices totals $60,000 and administrative personnel is estimated at $10,000.

UA: The University of Alberta made an annual cash contribution of $45,000 and released the site director quarter-time. In-kind support of offices totals $60,000 and administrative personnel is estimated at $10,000.

UBC: The University of British Columbia made an annual cash contribution of $95,000. The Director is released full-time. The site-director and the chair of the Scientific Review Panel were each released quarter-time. In-kind support for administrative offices is estimated at $160,000. As well, the university maintains PIMS financial accounts at an estimated in-kind annual cost of $30,000.

UC: The University of Calgary made an annual cash contribution of $40,000 and released the site director quarter-time. In-kind support of offices totals $60,000 and administrative personnel is estimated at $10,000.

UVic: The University of Victoria makes an annual cash contribution of $40,000 and released the site director quarter-time. In-kind support of offices totals $60,000 and administrative personnel is estimated at $10,000.

U Lethbridge: The University of Lethbridge, as an affiliate university of PIMS, makes annual cash contributions of $5,000.

9.2 Other Contributions

In the table below, we have only outlined the operating budget of PIMS. However, this tells only a part of the story since it does not describe the contributions to PIMS scientists and events that did not flow through the PIMS central accounts. Here is a brief description of such indirect contributions.

University Infrastructure: PIMS has offices at all five campuses. Computational facilities and some administration is also provided. Beginning June 1999, the PIMS central office at UBC will be using a 4,800 sq.ft research facility that will accomodate up to 30 offices as well as a scientific computing Lab and a reading room for about 20 researchers. Similarly, SFU has provided PIMS 2,500 sq.ft. of office space that will allow up to 15 scientists to be accomodated.

Additional support for Industrial PDFs: The PIMS contributions to the 12 industrial postdoctoral fellows ($10K each) have essentially been matched (on a 2 to 1 basis) by the corresponding industrial partners.

Additional support for Scientific PDFs: The PIMS contributions to the other 9 postdoctoral fellows ($10K each) have essentially been matched (on a 2 to 1 basis) by research grants from their supervisors and by stipends for teaching from their associated departments.

Equipment support: SunMicrosystems have awarded the PIMS-UBC Sunsite substantial computer equipments evaluated at more than $130,000.

Conference support: Most conferences have also been supported by registration fees and have sometimes been co-sponsored by other organizations.

Corporate support: This has materialized through contributions towards official receptions and banquets connected to the scientific events, for example those connected to the thematic programme on mathematical finance: Frank Russel Company, Falcon asset Management, IBM, etc...

Industrial support: The *Problem Solving Workshop*, the *Workshop on computer security*, the *workshop on coding theory and cryptography* (among others) have also been partially supported by direct contributions from the industrial participants.

Education support: Most educational events have been also co-sponsored by schools, provincial ministries of education and professional societies.

Partners support: Part of the salary of the PIMS industrial facilitator in BC has been provided by CICSR: The Center for Integrated Computer Systems Research.

9.3 Financial statement

	NSERC	ISTA	ASRA	Univ.	Other	Total
Scientific Personnel						
PIMS Research fellows			6000	28500		34500
Postdoctoral Fellows				24892	60000	84892
Release Time				38000		38000
Stipends				10250		10250
Subtotal:			**6000**	**101642**	**60000**	**167642**
Scientific programs						
Thematic Programme	93805				2616	96421
Workshops and conferences	1000			5000	40506	46506
Distinguished Lecture series	11270					11270
Can. Undergrad. Math. Conf	4841					4841
Subtotal:	**110916**			**5000**	**43122**	**159038**
Industrial Programs						
Problem Solving Programme*	4259		10000			14259
Indust. Training Programme		28678				28678
Industrial Workshops	14000	1383	7000		4971	27354
Industrial facilitators		18858	40000			58858
Indust. Postdoctoral Fellows	70000	20000	30000			120000
Subtotal	**88259**	**68919**	**87000**	**0**	**4971**	**249149**
Education Programs						
Math evenings in the schools				2126		2126
Math on internet	2700					2700
Math Olympiads			3000			3000
Alberta initiatives			5000			5000
Changing the Culture II	3232					3232
Graduate Week-end II	9000					9000
Subtotal:	**14932**		**8000**	**2126**		**25058**
Tech-based maths						
PIMS-UBC Sunsite		32162				32162
KnotPlot	10000					10000
Subtotal:	**10000**	**32162**				**42162**
Administration						
Personnel Salaries	18458		9000	70511		97969
Office expenses				42687		42687
Board&Executive meetings				15200		15200
Special events (Site visit, etc)				12403		12403
Subtotal:	**18458**		**9000**	**140801**		**168259**
Total Expenses	**242565**	**101081**	**110000**	**249569**	**108093**	**811308**
Income						
Carry-forward from 97/98	52781	10531		-34041		
Operating grant 98/99	200000	97500	110000	280000	115000	802500
Total Income	**252781**	**108031**	**110000**	**245959**	**115000**	**831771**

PIMS Operating Budget 1998/99

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